MAY 25 1948

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The curved earth

Vol. [illegible]
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The World's Northernmost Sundial

Cancer a Lobster for the Nonce

Stars for June

In Focus

A PICTURE of the future? Popular articles in today's newspapers and magazines often tell about the many and unusual sights that will be visible to the eyes of the first earthmen to reach the moon. Were it possible to make a flight to our satellite, set up a telescope of 2,400 power and point it toward the southwestern corner of the United States, one might see and photograph much the same scene as our front-cover picture this month.

Taken from a height of 101 miles at the peak of the trajectory of the 20th V-2 rocket to be launched in America, March 7, 1947, the composite photograph covers more than 500,000 square miles of the United States and Mexico, chiefly the state of Arizona. If a similar picture were taken in the East, it could easily have included both New York and Chicago. The four separate photographs do not match exactly due to the varying camera angles.

The photographic equipment for these pictures was installed under a program of the Naval Research Laboratory which had as one of its primary purposes the acquiring of knowledge of the various motions executed by the missile in its traverse of the upper atmosphere. Two K-25 aircraft cameras were operated automatically on 24-volt power and symmetrically mounted in opposite sides of the midsection of the rocket. A right-angle prism in front of each lens directed the field of view toward the tail at an angle of 20 degrees to the axis of the V-2. Each camera made 55 exposures on 4x5-inch infrared reconnaissance base film through a Wratten 25A filter. The exposure was 1/500 second at f/11, but examination of the results showed that more normal negatives would probably have been obtained if a stop of f/8 had been employed.

The curvature of the earth is a prominent feature of these first pictures ever to be taken from altitudes greater than 100 miles. It is possible to recognize easily such surface features as the dark area of the Gulf of California in the upper left part of the scene. The peninsula of Lower California is beyond, and then at the extreme left a small part of the Pacific Ocean can be seen beneath a rather heavy layer of clouds which obscures the horizon. Extending to the right from the north end of the Gulf of California is the Colorado River. The Santa Cruz River is located about ⅞ of an inch below the northern tip of the gulf, and ⅜ of an inch below the Santa Cruz is the San Pedro River. A dry lake, the white area 2½ inches from the left-hand edge and 2¾ inches from the bottom of the picture, may also be seen. Playas Lake, in extreme southwestern New Mexico, is 1¾ inches from the left edge and 1¾ from the bottom of the picture. Somewhat to the left and below is the dark area of the Hatchet Mountains, but White Sands Proving Ground is off the scene. Five eighths of an inch from the right side and 3⅜ inches from the bottom of the engraving may be seen dark spots which are probably the mountains to the north of Flagstaff, Ariz.

SKY and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*; HELEN S. FEDERER, *Managing Editor*

The Roosevelt Reservoir on the Salt River and the Coolidge Reservoir on the Gila River appear as tiny dark patches situated, respectively, 5 3/16 and 4½ inches from the left edge, and 3⅝ and 3¼ inches from the bottom of the picture.

Along the distant horizon clouds obscure detail of the earth's curved surface. From the great height formations which to an observer on the ground seem to cover nearly the whole sky are small and insignificant. Note the shadows of individual clouds, and the wide variety of cloud forms.

The cameras were pointing southwest when these pictures were taken, the rocket being inclined toward the northeast at a zenith angle of approximately 10 degrees. The V-2 rose vertically from the launching site, tilting gradually toward the north during the burning period. At the point at which the fuel was spent, 63 seconds after take-off, the rocket had a zenith angle of seven degrees. The pictures in the composite were taken 227 seconds after the take-off. Explosive charges at the base of the warhead and the junction of the midsection and tail were detonated 330 seconds after take-off, and the rocket broke up shortly afterward as it entered the denser portions of the atmosphere. Both cameras were recovered the following day, one of them partially destroyed by the impact.

Two other photographs taken on this same rocket flight are reproduced on page 196. The upper central section of the left-hand picture on that page is shown again in more detail in the other photograph of the pair. This is the region of White Sands Proving Ground. Various details, and even some of the cloud formations, can be identified in both views.

The right-hand picture was made first, 81 seconds after take-off at an altitude of 37 miles with the camera pointing west. The later photo was made at 85 miles height, 155 seconds after take-off. The camera was pointing southwest.

The front-cover picture and most of the above information are from Naval Research Laboratory Report No. R-3083, "Photography from the V-2 Rocket at Altitudes Ranging up to 160 Kilometers," by T. A. Bergstralh.

Discussion of this month's back-cover reproduction of the Andromeda nebula will be found on page 198.

VOL. VII, NO. 8
WHOLE NUMBER 80

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JUNE, 1948

COVER: A composite photograph of the earth, taken on the rocket flight of March 7, 1947, shows a vast area of the southwestern portion of the United States as seen from 101 miles above the surface. Naval Research Laboratory photograph. (See In Focus.)

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BACK COVER: The central portion of the Great Nebula in Andromeda, photographed on August 19, 1933, by Dr. John C. Duncan, with the 100-inch Hooker reflector at Mount Wilson Observatory. A Ross zero corrector was used, and the exposure was 2½ hours. (See page 198.)

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As our starbeam passes Alpha Centauri, whose bright image is just to the right of the dark cloud that stretches horizontally across the center of this picture, he is only 4.3 light-years from his destination, Earth. He notices that one of the components of Alpha Centauri is a yellow star of nearly the same brightness as the sun, while the other component is orange, and fainter. Just to the right of Alpha in the picture is Beta Centauri, a blue star 1,400 times brighter than the sun, which the starbeam passed some 185 years earlier. Photograph of the southern Milky Way by Harvard College Observatory.

Adventures of a Starbeam

BY PAUL W. MERRILL, *Mount Wilson Observatory*

WHEN YOU LOOK at a star through a telescope (or for that matter with the naked eye), you witness the final adventure of a starbeam as it plunges headlong into your retina. There it expires in a tiny flash of electronic energy, the circumstances of which are telegraphed to the brain, and the star is seen. The vision will persist as long as you keep looking because additional beams arrive from the star in a steady stream. This gives an interesting and valuable continuity. But let us now consider a quite different kind of continuity—that connected with an individual starbeam. Before the starbeam entered your eye, it was for a moment in the telescope; before that in the near-by atmosphere; still earlier in the stratosphere. Before it entered the earth's upper atmosphere, it was for a few hours in interplanetary space within the bounds of our solar system; for some years before that in interstellar space. Thus we trace it back to the surface of the star of its origin. Where was it before that?

We seem to be going at this thing backward. You might not care for a biography in which the hero's career was traced in such a way — from the grave back to the cradle. Let us therefore begin again and describe the life of a starbeam in the normal sequence.

Before we relate the chronological story of the life and adventures of a starbeam, however, a few words about its not-so-humble origin, the star from whence it came. Seen from the earth the star appears as a faint point of light, but actually it is a huge incandescent gaseous powerhouse, more than a million miles in diameter. The most important thing it does is to radiate energy — light and heat. A star's radiation is pretty big business; at least we would think so if we had to pay for it. Let us base an illustration on our best-known star, the sun. As stars go, he is by no means outstanding; some stars outshine him a thousand times. He is notable only because he is so close to us (only 93 million miles away) and because we so greatly enjoy his contributions to our welfare. He really does a lot for us, just how much we seldom pause to think. The cash value of solar energy falling on the earth every minute is 60 billion dollars. If the amount seems incredible, consider the expense incurred in warming a small building by electricity. Imagine what it would cost you to warm Los Angeles County or the State of California. Yet the sun warms the whole earth many degrees every day.

But to come back to our 60 billion dollars per minute. This is a very small part of the whole story. As seen from the sun, the earth is but a tiny speck in the sky; but there is every reason to believe that the sun radiates equally in all directions. What fraction of the whole sky does the earth cover as seen from the sun? Only one part in 2,200,000,000. Hence, to get the total cash value of the sun's radiation each minute, we must multiply 60 billion dollars by more than two billion. And the sun is just a dwarf star; for a giant, multiply again by a thousand.

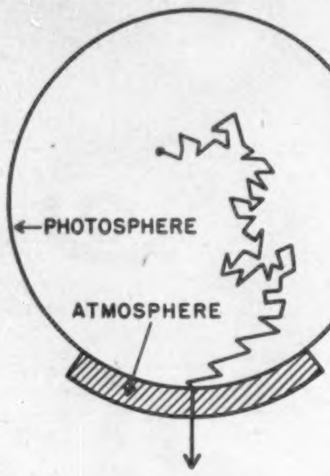
Our hero, an individual starbeam, carries from his home star an infinitesimal fraction of this enormous energy. But he doesn't get away with it easily. His main career begins with his escape from the star's visible surface, but before that he had to bring up his little load of energy from the vast reservoir in the intensely hot interior. And he received a terrible beating in the process — unhappy years of constant battle in a fearful inferno. The fact is that our light beam was able to escape only after many futile attempts. The first million million tries were the hardest. Many a dash for liberty was thwarted by an unfriendly atom that stopped and held him. But the period of captivity was never long, usually about a hundred-millionth of a second; then another dash and another capture.

Thus in the course of a million years or so our determined fugitive works his way from some point in the star's interior to a port of embarkation at the surface, ready to take off. At the very last moment, some of his more vulnerable colleagues are struck down by alert atoms in the star's atmosphere. The other light waves rush on; but narrow gaps in the ranks may still be detected years later when the starbeams undergo spectroscopic inspection in terrestrial observatories.

Some of the star's *atoms* also were afflicted with a desire to break away, but very few of them were able to elude the powerful and unbribable jailer, gravity. According to the theory of relativity, gravity makes a grab also at every light wave. But light waves are much faster than atoms and pay little attention to him. In an average star they notice the clutch of gravity about as much as a speeding fullback notices a would-be tackler who barely touches

him with a fully outstretched finger.

The great moment of the take-off is now at hand; our light beam is released for the last time from captivity in the star's photosphere, and heads for the earth. After a hectic career of short, violent, zigzag dashes within the star,



An incredible number of attempts to escape from the star's interior are made by the light beam before finally passing through the star's atmosphere to the earth. Engraving, courtesy of the Astronomical Society of the Pacific.

he now begins a fine untroubled vacation. What a relief is the long, straight, cool path in interstellar space.

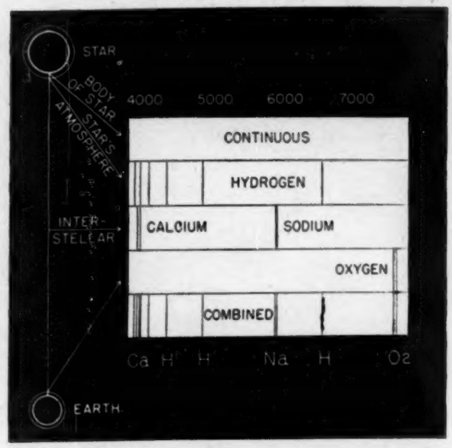
Out there, however, he does face a long, mild battle of attrition with the geometrical agents of the law of the inverse square (of distance traveled), which by dispersing his formation over an ever-widening front weaken him progressively as he marches along. He resists well, however, wasting no energy on unnecessary maneuvers.

Along the way the light beam sees many stars and a few nebulae, just the same kind of a galactic view we get from the earth. As he proceeds, the constellations weave and twist about in a strange way; straight ahead the configurations grow larger, while directly behind they close in; at right angles to his path they are apparently rushing backward. We humans get these same geometrical effects as we travel through space aboard the solar system; but the apparent motions are very slow because we travel so much slower than light.

Our starbeam may have some casual skirmishes with minor enemies while passing through the vast galactic abyss, where abound dirt and fumes diluted to an almost innocuous tenuity. Dust clouds sometimes oppose him; if he plows through them, his blue and violet cohorts are especially decimated, leaving him ruddy, like the sun seen through smoke. Atoms in gaseous array do some precision sniping, picking off selected individuals. The most effective snipers are atoms of sodium and calcium, which always aim at yellow and violet beams, respectively. Happily these attacks are not very devastating, and our light beam coasts along at full speed, reaching his terrestrial destination in good condition.

As the starbeam approaches the solar system, new and beautiful sights present themselves. The sun itself, at first a mere point of light, gradually develops into a small disk which grows larger, but which has constantly the same surface brightness with which we on earth are familiar. The corona should become visible as a solar halo projected against the blackness of space. It would not be smothered with sky light as from the surface of the earth, but the intense light of the sun itself might make the corona difficult to see. The planets are gorgeous. Since they are globes, one half in darkness, the other half in sunshine, their phases change as the light beam rushes by. He might see Jupiter and Saturn and Mars as crescents — a privilege never granted to earth dwellers.

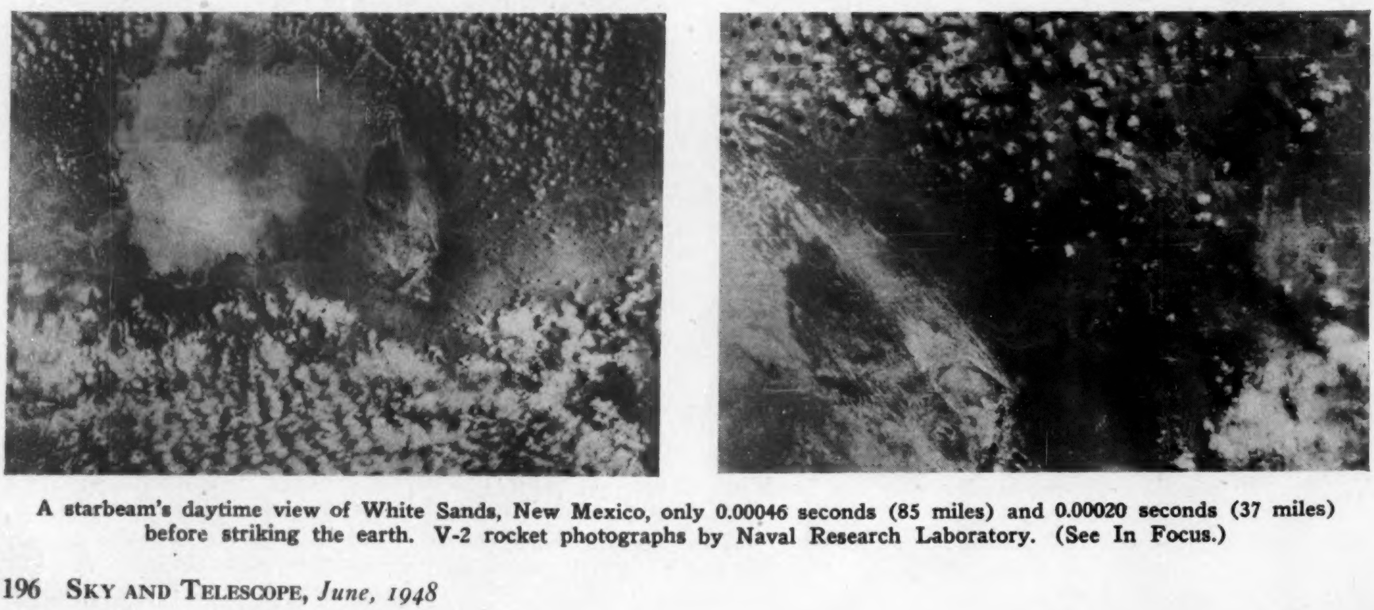
On his approach to the earth, things happen fast. In the rare upper atmosphere he might encounter thin flocks of electrons stirring up the northern lights. A meteor might challenge him to a race, but our starbeam would pass him as an automobile passes a snail. Finally, as he descends into the denser lower atmosphere our customs inspectors are out to meet him. First Ozone advises him that importation of ultraviolet light beyond a certain range (2950 angstroms) is entirely prohibited, and he is deprived of all this kind of baggage he brought along, be it much or little. Next, Water Vapor and ordinary Mo-



Many factors influence the nature of light passing from a star to the earth and leave their "marks" on the spectrum.

lecular Oxygen exact fees of red and infrared light payable in a manner very precisely specified. Water, if in an unpleasant, condensed mood, may block his way so vigorously that the light beam capitulates in mid-air only a forty-thousandth of a second from the earth. Our beam is more fortunate, and with only a slight nick taken out of him goes right along to his big and final adventure.

One of his very last acts is to stage a home-star reunion. Beams from the same star have in their travels tended to disperse in ever-widening cones and to intermingle with travelers from other stars. It would be good fun if some of them could have an old-fashioned get-together to cheer for dear old stella mater. Such celebrations had indeed



A starbeam's daytime view of White Sands, New Mexico, only 0.00046 seconds (85 miles) and 0.00020 seconds (37 miles) before striking the earth. V-2 rocket photographs by Naval Research Laboratory. (See In Focus.)

been held for centuries at many a retina, but the meetings were poorly attended and the cheers not very loud. Finally Galileo induced larger numbers of the divergent starbeams to rally at the focus of a lens. Thus telescopes sort out the interlacing light rays from myriads of stars, bringing together again those that years previously had started off together. This act of a bundle of rays of light from a single origin returning again to some other point is so common that we may forget how wonderful it is, and how helpful. This would be a strange and a difficult world if light rays could not be so bent as to form images of their points of origin.

The last act of a starbeam after traversing the telescope is a sudden transformation into a little splash of energy at the surface which finally blocks its progress. It is like a stone being thrown into a pond, with the stone disintegrating and completely disappearing at the moment of impact, the splash being its only memorial. Light splashes are of two kinds, molecular and electronic. In the molecular splash, molecules at the point of impact are thrown about, thus causing a slight warming of the surface which may be measured by a bolometer, a radiometer, or a thermocouple. At the focus of the 100-inch telescope, a minute receiver may be warmed as much as 1/100 of a degree centigrade by the image of a very bright, red star.

The electronic splash is more important for astronomy. In it an electron belonging to an atom is either displaced or completely detached. This may happen at the human retina, which telegraphs the news to the brain and a star is seen; or at a point on a photographic plate which becomes a developable image; or at the surface of a photocell (electric eye) where an electron is detached and the light intensity, even if feeble, can be determined by delicate electrical measurements.

A starbeam has a wonderful memory and can tell many tall but true tales of the strange and distant region from which it came. By far the most detailed account is obtained if each color is allowed to speak separately. This occurs when the colors are sorted out and distributed according to wave length in a neat row — the spectrum. Marvelous stories are then related in a spectroscopic cipher which is not too difficult to decode. These spectroscopic stories constitute a large part of our present knowledge of the heavenly bodies.

The biography of a starbeam shows that its greatest adventures occur at the beginning and at the end of its life. In its early years inside the star where the temperature was a pitiless 30,000,000° centigrade, it was kicked around violently millions of times a second. Then came the long journey through interstellar space about 3° above absolute zero, with relatively little excitement. Next, there was an encounter with the customs officials of the earth's atmosphere, a few fast acrobatics inside a telescope, a brief reunion with other travelers from the old home star, and then the climax, a sudden tragic death at the inside surface of a little sphere called an eye.

This, I think, is where we came in. We have completed a voyage with a starbeam. If it is clear tonight, why not attend a starbeam reunion; perhaps the electronic splash in your retina will evoke in your brain that mysterious phenomenon, a thought. And thoughts are far-reaching; they can travel the length and breadth of our great universe faster even than starbeams.

TERMINOLOGY TALKS-- J. Hugh Pruett

Fireballs, Bolides, Detonating Meteors

An unusually brilliant meteor is termed a fireball. Some observers would apply this name to any meteor brighter than Jupiter or Venus; one writer has suggested that any meteor bright enough to prompt observers to report it should be considered a fireball. Occasionally such objects are many times brighter than the full moon and cast strong shadows.

A bolide is usually defined as a fireball which appears to explode during flight. A detonating meteor is a fireball which produces an audible disturbance as it rushes through the atmosphere.

Trains, Trails

The delicate white line sometimes left on the sky, and which marks the path of part of the meteor's flight, is known as a *train*. These trains seem to be of two types. The self-luminous variety is generally formed in the space between 60 and 45 miles above the earth's surface, and can be seen only at night. A daytime fireball often leaves a long smoke train at much lower levels. The smoke trains are best observed in twilight while the sun is still shining upon them. They are not self-luminous as are the higher type.

A meteor train is sometimes incorrectly called a *trail*. The latter term belongs more properly to the streak recorded on a photograph as the meteor makes its rapid flight across the sky.

Sporadic Meteors

On almost any clear night the diligent watcher of the skies is rewarded by the sight of an occasional small meteor tracing a short arc among the stars. If the sky is moonless, five to 10 meteors may be seen in an hour. They come from almost any part of the heavens and go in various directions. Each one usually seems "on its own" and with no interest in the others. Such objects are known as *sporadic*, or stray, meteors.

Shower Meteors

At certain times of the year, and usually recurring annually, the hourly rates of meteors are easily observed to be much greater than that mentioned above. The occasional strays are still "on the prowl" across the great starry spaces, but real packs with greater boldness and determination temporarily dominate the stellar scene. For any certain display of these *shower* meteors, they appear to rush onto the field from a definite entrance on the celestial sphere, a location known as the *radiant* of the shower.

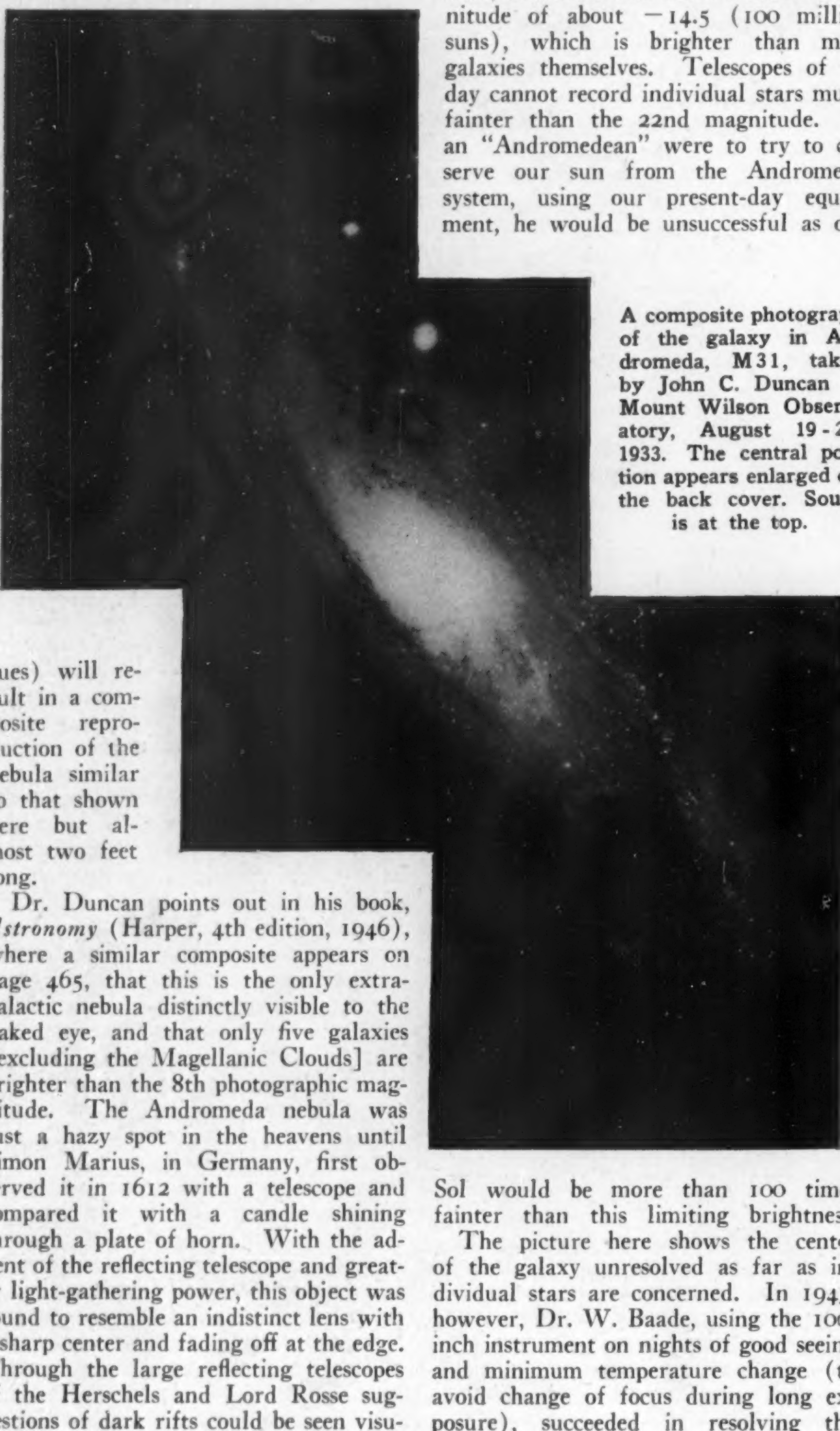
Whether the meteors belonging to a shower are seen to start near the radiant or far from it, imaginary lines drawn along their visible paths and continued backwards will cross at this location, from which they seem, therefore, to originate. Meteors behaving in this manner are said to belong to a definite shower, but the word "shower" is quite misleading, for seldom is more than one luminous "drop" visible at a time. Nevertheless, there have been a few occasions in the past when the term was almost applicable. The latest was on October 9, 1946, when in North America nearly 100 meteors a minute dashed across the moonlit sky into the view of fortunate observers.

The name of the shower comes from the constellation in which the radiant is located. The Draconids of October 9, 1946, radiated from the head of Draco, the Dragon. A consistent and familiar shower is that of the Perseids, at their best around August 12th. Others well known are the Orionids, at maximum about October 20th; Leonids, November 16th; and Geminids, December 12th. At times in the past the Leonids have staged exciting displays, but ordinarily the Perseids are the most prolific, producing at maximum 60 to 80 meteors per hour for a single observer.

These shower meteors travel around the sun in definite orbits. The reason we see any one display once a year is that the earth at a certain time comes to the place where its orbit is very close to the path of the meteor stream. These particles of matter are traveling in approximately parallel paths, forming a stream often millions of miles wide. The pieces which are swept up by the earth are burned by the intense heat produced by friction with our atmosphere, and are lost forever to their fellow travelers in space. Those we fail to encounter, almost 100 per cent of them, hurry merrily on and are safely beyond terrestrial attack. At some future encounters part of the escapees will streak our night skies.

The Great Nebula in Andromeda

WITH this month's back-cover picture of the nucleus of the Great Nebula in Andromeda, our series of reproductions of this splendid object is complete. The photographs are by Dr. John C. Duncan, Whitin Observatory, Wellesley College, made in August, 1933, with the 100-inch Hooker reflector at Mount Wilson Observatory. Careful trimming and mounting of these three pictures (this one and the back covers of the February and April issues) will result in a composite reproduction of the nebula similar to that shown here but almost two feet long.



A composite photograph of the galaxy in Andromeda, M31, taken by John C. Duncan at Mount Wilson Observatory, August 19 - 20, 1933. The central portion appears enlarged on the back cover. South is at the top.

Dr. Duncan points out in his book, *Astronomy* (Harper, 4th edition, 1946), where a similar composite appears on page 465, that this is the only extragalactic nebula distinctly visible to the naked eye, and that only five galaxies [excluding the Magellanic Clouds] are brighter than the 8th photographic magnitude. The Andromeda nebula was just a hazy spot in the heavens until Simon Marius, in Germany, first observed it in 1612 with a telescope and compared it with a candle shining through a plate of horn. With the advent of the reflecting telescope and greater light-gathering power, this object was found to resemble an indistinct lens with a sharp center and fading off at the edge. Through the large reflecting telescopes of the Herschels and Lord Rosse suggestions of dark rifts could be seen visually. It remained for photography to record the individual characteristics of the numerous objects that go to make up this brightest galaxy in Andromeda.

Star clouds, globular clusters, open clusters, and clouds of nebulosity have been found in this great stellar system. In only 20 years more than 100 novae have been observed, chiefly in the region of its nucleus. Forty Cepheid variable stars are known and watched by observatories with large telescopes. The famous supernova of 1885, S Andromedae, reached a maximum absolute magnitude of about -14.5 (100 million suns), which is brighter than most galaxies themselves. Telescopes of today cannot record individual stars much fainter than the 22nd magnitude. If an "Andromedean" were to try to observe our sun from the Andromeda system, using our present-day equipment, he would be unsuccessful as old Sol would be more than 100 times fainter than this limiting brightness.

The picture here shows the center of the galaxy unresolved as far as individual stars are concerned. In 1943, however, Dr. W. Baade, using the 100-inch instrument on nights of good seeing and minimum temperature change (to avoid change of focus during long exposure), succeeded in resolving the nucleus of M31 into great numbers of 21st-magnitude stars. He employed red-sensitive plates and a red filter to cut down on fogging by the light of the sky.

In Dr. Duncan's pictures, the resolution of the spiral arms into individual stars, star clusters, and clouds of interstellar gas is quite evident. NGC 206 is the outstanding star cloud visible in the upper left portion of the composite, and near the center of the area reproduced in February. A large white image, 1¼ inches from the top of this month's cover, is the elliptical nebula M32, a companion of M31. Another and more distant companion, NGC 205, is included on the original negative of the nucleus but had to be excluded from the reproductions because of the back-cover proportions. One example of an open cluster may be found on the February picture, about 3½ inches from the top and the same distance from the left side of the reproduction; its image is compact but irregular in outline.

At the Newtonian focus of the 100-inch telescope the image of the main body of this galaxy is about two feet in length. Most authorities agree that this portion of the system measures 160 minutes of arc (2 2/3 degrees) long and 40 minutes wide on ordinary photographs with large reflectors. Microdensitometer tracings show much greater extent than this. By means of the magnitudes and periods of its Cepheid variables, the distance of the Andromeda system is now placed near 805,000 light-years. That far away, an angle of one degree corresponds to 14,000 light-years, and is about 12 inches long on the scale of the back-cover reproductions. The enlargement is to about 4/3 of the original scale of the 100-inch plates, for which the focal length of 508 inches scales nearly nine inches to a degree.

Fortunately for observers on the earth, the great Andromeda spiral is seen with its plane tipped about 15 degrees to the line of sight. This makes it possible to observe the spiral structure and to study to better advantage this most important of our neighbors.

200-INCH OPENING

The dedication at Palomar Mountain will be held inside the observatory at 2:00 p.m. on June 3rd. The program will be limited to short addresses by Dr. Vannevar Bush, president of the Carnegie Institution of Washington; Dr. Raymond B. Fosdick, president of the Rockefeller Foundation; Dr. Max Mason, chairman of the observatory council; Dr. Ira S. Bowen, director of the Mount Wilson and Palomar Observatories; and Dr. L. A. DuBridge, president of California Institute of Technology, who will also preside over the ceremonies.

Attendance will be by invitation only, and it is estimated that between 800 and 1,000 persons will be present.

Color in the Sky

By Robert R. Coles, *Hayden Planetarium*

WHAT A STRANGE and uninteresting world this would be without color! It is said that some animals see everything in shades of gray — they are entirely unaware of the color range from red through violet that we enjoy. Certainly much of the beauty of the sky picture is derived from the varied colors that it exhibits. Some of these are obvious to the most casual observer. Some are revealed through the telescope, while others are brought to light only by the spectroscope.

In a certain sense, we might say that all the colors that we experience on the earth have their origin in the sky, for it is the source of the illumination whereby the green of grass and leaves, the blue of water, and the brilliance of snow are derived. But many of the colors seen in the sky are so obvious that we take them for granted. Among these are the blue sky, the symphony of dawn and sunset, the colorful arch of the rainbow, and the shimmering splendor of the aurora.

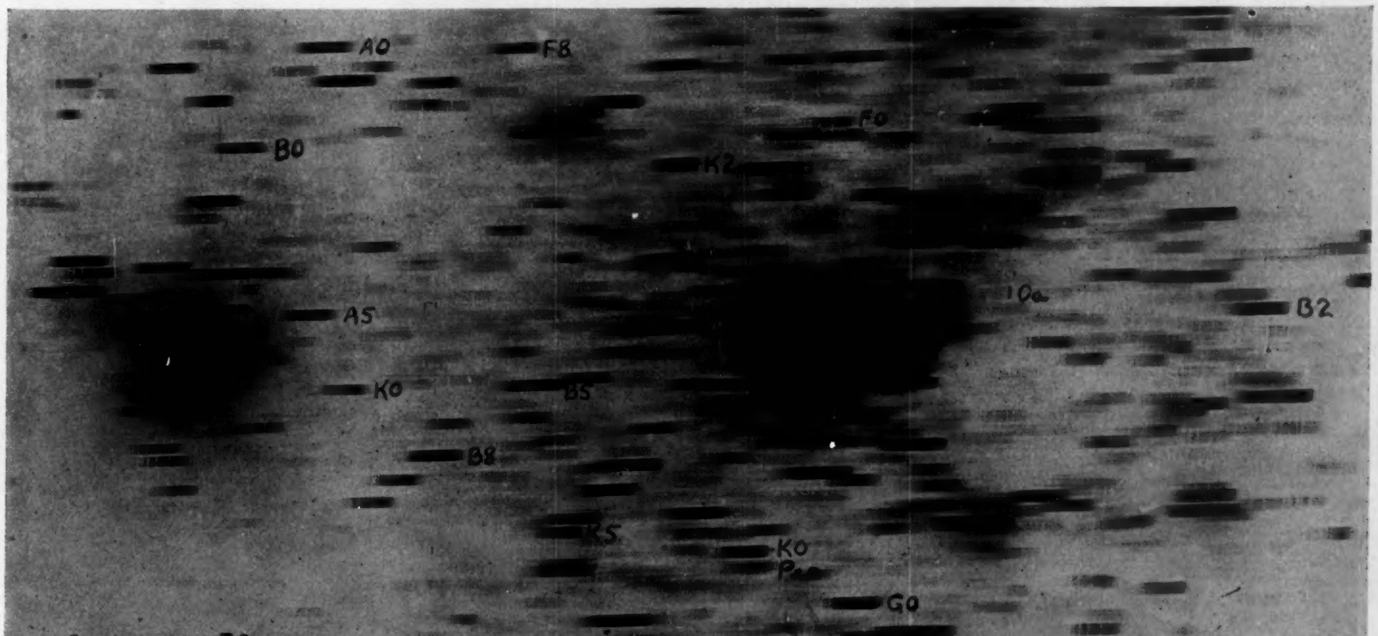
Perhaps some will be surprised, however, to learn that the color of the sky itself is not actually blue. It is black. The various shades of blue that we observe come from the light of the sun by day, and the light of the night sky is derived from the moon and stars and a permanent auroral glow. When the light from celestial bodies enters the earth's atmosphere the shorter wave lengths, that is, the bluer colors, are scattered about to give the effect of blueness. The scattering is caused by the billions of minute dust particles and molecules of air; also by water vapor. Because of the greater density of the atmosphere near the surface of the earth and the larger concentration of dust particles, the sky appears of a lighter blue there than at higher altitudes. As observed from the peaks of lofty mountains or from a high-flying airplane, it appears darker, and in the uppermost levels of the atmosphere the sky is nearly black, so that the stars may be seen when the sun is above the horizon. If the earth were without an atmosphere, the heavens would appear black and the stars would be visible by day.

We have all witnessed sunsets that would challenge the talents of the greatest artist, for nature seems capable of working a magic with hues and colors that no human artist can equal. Her repertoire is endless and apparently no two sunsets are identical. Such a spectacle is caused by the light of the setting sun penetrating different depths of atmosphere, which filter out colors of various wave lengths and permit other colors to illuminate the cloud forms beyond in such a way as to produce the many striking motifs that we observe.

Many color phenomena in the sky lie on the border that separates meteorology and astronomy, and are therefore of interest in both sciences. Among these effects are the changing color of the rising or setting moon and sun, rainbows, solar and lunar halos and coronas (not to be confused with the sun's corona), and the northern and southern lights.

On the other hand, the pageantry of color that accompanies a total eclipse of the sun belongs in the realm of astronomy. The steady decrease in general illumination as the moon covers the sun is like a change of lighting in a great theatrical production, climaxed as Baily's beads and the diamond ring appear. During totality the pearly gray corona bursts forth in all its magnificent splendor and delicate shadings of color. Keen observers and those with binoculars or telescopes thrill to the crimson brilliance of the sun's prominences seen jutting beyond the black disk of the moon. When the eclipse spectacle is repeated in reverse, the observer, once more in full daylight, is left with the feeling of having experienced one of the most awe-inspiring of all celestial sights.

While not as spectacular as a total solar eclipse, a total eclipse of the moon gives another exhibition of color changes in the sky. Far more people have ob-



On objective-prism photographs such as this, colors of the stars can be determined from their spectra. The A stars are white; G stars are yellow, like the sun; K stars are orange. Harvard College Observatory photograph.

served total lunar than have seen total solar eclipses, due to the fact that lunar eclipses may be seen from more than half the surface of the earth. As the moon enters the penumbra of the earth's shadow there is little, if any, perceptible change in its apparent brightness. However, as it crosses the edge of the umbra a dark orange hue becomes apparent on its eastern limb. This slowly creeps across the lunar disk, and when finally our satellite becomes completely immersed in the cone-shaped shadow of the earth it appears to be bathed in a coppery red. This effect is caused by the long wave lengths of sunlight that are refracted by the atmosphere of the earth and bent into the region of the shadow. Were it not for this refraction of the red rays, the earth's shadow would be completely dark and the moon would disappear during totality. On occasion, when the twilight zone of the earth at eclipse time is heavily clouded much of the way around the earth, little light is refracted into the shadow and the moon is barely visible at mid-eclipse.

Anyone who has carefully studied the night sky is well aware of the wide range of color in the planets and stars. Some stars are red, such as Antares and Betelgeuse; Arcturus is orange, as is Aldebaran; Capella is yellow; Sirius is white. And through the telescope these colors become even more pronounced, while several double stars have strongly contrasting colors. One of the most interesting of these is Albireo, at the foot of the Northern Cross. It consists of two gems of rare beauty, one a golden yellow and the other blue. Another beautiful contrast with similar colors is that of the components of Almach, Gamma Andromedae.

The colors of the stars are indicators of their spectral classes, and probably the most important contribution that the concept of color makes to our understanding of the universe is in the spectra of both celestial and terrestrial objects. The rai-bow is a natural spectrum produced by the dispersion of sunlight into its component wave lengths, which appear to our eyes as various colors. Any schoolboy today can repeat Newton's experiment of nearly 300 years ago, when he showed that sunlight passed through a glass prism would emerge in a band of light that contained all the colors of the rainbow — from violet through red. Not only does the light of the sun give us a spectrum, but so does that from the planets, the stars, clusters, nebulae, and the millions of remote extragalactic systems.

From the simple discovery of Newton there has evolved the highly complex science of spectroscopy, by which we delve into the nature of matter and its physical and chemical characteristics everywhere in the universe. By capturing the light of celestial bodies and converting it into its component parts (wave lengths rather than colors, as most spectrographs take black-and-white spectrograms), astronomers are enabled to determine the chemical compositions of the stars, to measure their distances beyond the range possible by triangulation, to learn how they are moving through interstellar space, to study multiple systems, and to ascertain dozens of other interesting facts.

Color in the sky, as revealed by the spectroscope, has provided what is perhaps the most important weapon since the invention of the telescope for the purpose of extending the horizon of knowledge and probing the hidden secrets of the universe.

The World's Northernmost Sundial

By Howard P. Smith, Jr.

FAR TO THE NORTH, 10 degrees past the Arctic Circle, only 800 nautical miles from the north geographic pole, lies one of the world's most northerly permanent settlements. It is the little village of Thule, situated on the northwestern coast of that icy subcontinent called Greenland.

Thule (pronounced *too'-ly* by the natives), a favorite stopping place for arctic explorers and part-time home of the late great explorer Knud Rasmussen, is a double settlement: half Danish and half Eskimo. Probably 50 people live there the year around. Most maps indicate a settlement to the north of Thule known as Etah, but at the outbreak of World War II Denmark closed Etah, leaving Thule some hundred miles to the south as the northernmost permanent settlement in North America near the close of 1947.

The sundial is located on the north side of the church. In the photograph the landmark Mount Dundas appears prominently in the background.

With a name derived from the ancient phrase *ultima thule,* or jumping off place, Thule is remarkable for several things. It contains, for instance, one of the world's most northerly churches (Lutheran) where the Eskimos read prayer books printed in their own tongue. There is the northernmost railroad (to my knowledge), all of 200 feet long, from the seashore to a warehouse to facilitate the unloading and storing of supplies which arrive aboard the one or two ships each year.

But to astronomical enthusiasts a major point of interest is what is probably the world's northernmost sundial. Nowhere else on the globe have I heard of a sundial with as steep an angle on the shadow-forming upright or gnomon. The geographical co-ordinates of Thule are 76° 33½′ north, 68° 48′ west, and measurement of the angle of the upright shows it to be about 76½ degrees. During the summer, of course, this sundial can be used to tell the time 24 hours a day. Thule is so far north that the sun is above the horizon continuously for three months, and above the horizon for a while each day for another five months. In fact, at midnight on June 21st, the sun is still 10 degrees above the horizon as it passes the lower branch of the meridian.

The bronze sundial plate is engraved

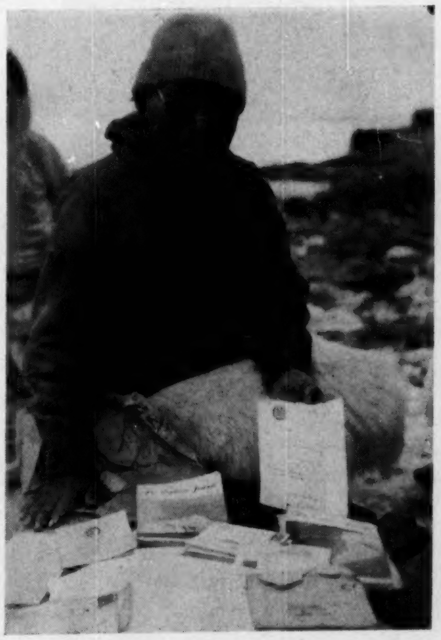
Twenty minutes past midnight is shown on this picture of the Thule sundial. Note the almost vertical angle of the gnomon.

Some of the neighborhood Eskimos gathered in front of one of the sod huts that serve them as permanent homes. Note that women and girls wear sealskin boots that come up to their hips, whereas men and boys wear polar bear trousers to below their knees, and then boots. However, some Eskimos wear a mixture of native and Western clothes as one can find by studying the picture.

with the name of its donor, *Cornelius Knudsen, Danmark,* and shows a double 12-hour scale rather than a 24-hour marking. Because it was rather impractical for me to photograph the midnight sun, I decided to photograph the sundial as it indicated midnight; the accompanying picture was taken by natural light near midnight on June 6th. The standard time at Thule is four hours less than Greenwich time, and the sundial appears to be set within 10 minutes of local meridian time. There is a discrepancy of 35 minutes between the two times. Note that due to the confusion concerning the correctness of the sundial setting, the "midnight" picture actually was taken some time after midnight.

In Greenland there are at least a dozen sites of Eskimo villages extending 150 miles north of Thule, ranging in size from two to possibly a dozen sod huts, but these are not necessarily occupied the year around. No Danes or other white persons live permanently north of Thule. There is only one permanent building at Etah now, and that occupied by an Eskimo. When explorer Donald B. MacMillan visited Etah in August, 1947, he found no activity; the Etah harbor is ice-free only from late June to September.

Two of the Eskimos who live in Thule are veterans of Admiral Peary's north pole expedition of 1908-09. They are Ootah and Harrigan. Ootah was one of the several Eskimos to accompany Peary to the actual pole. Harrigan went only as far as Cape Columbia, the northern extremity of Ellesmere Island, and waited at camp for the return of Peary's party from their dash across 400 miles of polar sea ice to the pole and back. Harrigan was named by Peary's sailors when they found he had learned to say "Harrigan — that's me," after the song that was popular at the time. Ootah has a batch of clippings and printed matter pertaining to his trip and subsequent recognition, and he rushes to show them to any visitor who will appreciate them (he does not read any English). Among these papers are copies of the *Explorers Journal,* and a formal invitation to a dinner given by



Ootah proudly displays his valuable papers, his proof of the historic journey to the top of the world in which he took an active part.

Mr. and Mrs. Lowell Thomas for the New York Explorers Club.

The Eskimos live in sod huts, as shown in the picture. They live in igloos only when out on hunting trips. They have similar habits to the American Indian, in their hairdress and manner of carrying their young. All the area around Thule is not barren wasteland and rock, as might be imagined. There is a fluffy flower known as Arctic snow or Arctic cotton, and in the valleys grow thick grass and small flowers of varied colors during the summer. We saw caterpillars, honey bees, cocoons, butterflies, before all the snow was off the ground.

EYE VERSUS PICKUP DEVICES

An important paper on the sensitivity performance of the human eye, as compared with such light-sensitive devices as photographic film and electron image tubes used in television, appears in the February number of the *Journal* of the Optical Society of America. It is written by Albert Rose, of RCA Laboratories. Basically, he seeks to compare the actual performance of the eye with possible future performances of pickup devices as limited by statistical fluctuations (noise). Although about 100 incident quanta of light energy are needed to record on the eye as well as on film, the latter ceases to record at a few footlamberts luminance of a scene, while the eye can still transmit a picture at one millionth of a footlambert.

The large discrepancy between the eye and mechanical devices comes from the fact that as the scene luminance is decreased the signal received by the retina falls linearly while the noise associated with the signal falls as the square root of the scene luminance. The same relations hold for pickup tubes and film, but usually only over the relatively narrow light ranges for which they are normally used. In these ranges they act like ideal devices with a quantum efficiency about the same as that of the eye, but as the light intensity falls off the noise in a television amplifier, the shot noise in a scanning beam, and the fog in photographic film ruin their respective efficiencies. Dr. Rose considers that these limitations can eventually be overcome by future refinements in design and processes.

The bulk of the performance data of the eye can be summarized by that of an ideal picture pickup device operating with a quantum efficiency of five per cent at low lights and 0.5 per cent at high lights. Storage time of the ideal device, including the eye, averages 0.2 second. Matching the performance of the dark-adapted eye at very low levels of luminance is not likely soon to be attained, however, for this performance seems to depend upon some kind of gain factor which operates between the retina and the brain *after* the primary photo process has occurred in the eye.

Amateur Astronomers

Milwaukee Convention Plans

HEADQUARTERS for the second national convention of the Astronomical League, to be held in Milwaukee from July 3rd through July 5th, will be at Concordia College. This is about 2½ miles west of the center of the downtown area, between 31st and 33rd Sts., and between State St. and Kilbourn Ave. Registration will be on Saturday morning at Wunder Dormitory, 3215 W. State St., where visitors will also be housed and fed. The registration fee is $1.00. All interested persons may attend the convention.

Saturday, July 3

8:00 a.m.	Breakfast. Council meeting
9:00 a.m.	Registration
10:00 a.m.	Opening session. Greetings, papers, reports of activities
12:30 p.m.	Lunch
2:00 p.m.	Session for papers
3:00 p.m.	"Recent Investigations of the Sun's Radiation," Dr. Jack T. Wilson, Allis Chalmers Co.
4:00 p.m.	Business meeting
5:30 p.m.	Supper. Buses leave at 6:00 for Milwaukee Astronomical Society Observatory
6:30 p.m.	Evening visit and program at the observatory. (In case of bad weather an alternate program will be held.)

Sunday, July 4

8:30 a.m.	Breakfast. Council meeting
9:30 a.m.	General session. Papers. "The Burma Eclipse Expedition," E. A. Halbach
12:00 noon	Group photograph
12:30 p.m.	Banquet. "American Astronomical Society Meeting and Mount Palomar," C. A. Federer, Jr.
2:00 p.m.	Astronomical motion pictures. Section meetings
4:00 p.m.	Meeting of national council to hear committee reports
5:30 p.m.	Supper
6:00 p.m.	Buses leave for Yerkes Observatory
8:30 p.m.	Paper, "Recent Planetary Investigation at McDonald Observatory," by a member of the Yerkes staff

Monday, July 5

8:30 a.m.	Breakfast
9:30 a.m.	"Astronomy in South America," L. E. Peterson. Business meeting. Elections, announcements, reports, resolutions, etc.
12:00 noon	Adjournment of convention. Lunch
1:30 p.m.	North Central region business meeting.

Program. Because this is an official convention of the Astronomical League, all member organizations have been invited to send their suggestions on what matters of interest to include in the program to the undersigned, so that it may as completely as possible incorporate the needs and desires of everyone. The program here, as of the first week in May, is complete in its main points, but the final version may differ in some details.

Reservations should be made with Mr. Roy L. Dodd, 7918 Milwaukee Ave., Milwaukee 13, Wis. The rate for room and meals is five dollars a person per day. Those who are staying with friends or at hotels may take meals with the convention group; the cost of these is 75 cents for breakfast, $1.50 for the noon meal, and $1.00 for the evening meal.

Exhibits. As has been customary at past conventions, there will be an exhibit of telescopes and other equipment, devices, and gadgets by amateurs. If you wish to participate, notify Mr. Roy R. Lee, 3168 S. 97th St., Milwaukee 14, specifying what you have to exhibit. He will get in touch with you as to when and where to ship the material.

North Central region meeting. A business meeting of the North Central region on Sunday afternoon will follow the adjournment of the national convention.

Ross H. Bardell, president
Milwaukee Astronomical Society
623 W. State St., Milwaukee 3, Wis.

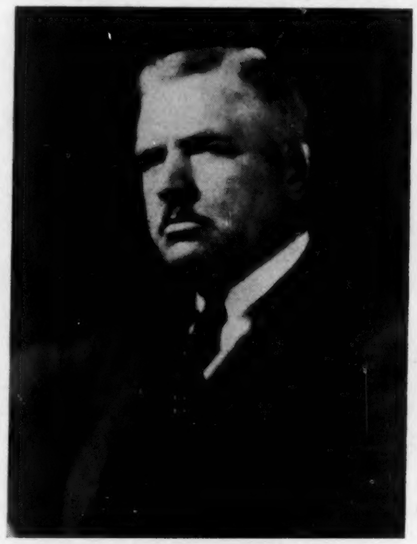
WILLIAM HENRY

ONE AFTERNOON during the last week in March, amateur astronomer William Henry was overcome with coronary thrombosis, from which he succumbed a week later, at Beekman Hospital. For years he was president of the department of astronomy of the Brooklyn Institute of Arts and Sciences. He was a member of the board of directors of the Amateur Astronomers Association at the American Museum of Natural History, and belonged to the American Astronomical Society and the American Association of Variable Star Observers.

William Henry came to this country from Scotland when a mere lad, and was educated at the old Pratt Institute in Brooklyn, where he majored in art. It was his artistic ability that proved so valuable in making his sunspot photographs and drawings. His collection of sun activity pictures was probably larger than that of any other amateur astronomer.

He was a commercial photographer, a profession he successfully pursued for over three decades, following a hectic career as a newspaper photographer. His first training was under William Zerbe, whom he succeeded on the staff of the New York *Herald*. Among his many experiences was the photographing of the first international yacht race in this country. He worked from a yacht hired by the *Herald* and sent the films by carrier pigeon to the home office in New York.

Also, while so employed, he was given a scant hour's notice to sail from Baltimore for Martinique on an ocean-going tug to take pictures of Mount Pelée in volcanic eruption. Soon after his arrival there, and while approaching the volcano for closer views, a new eruption of lava and red-hot cinders was ejected directly toward his party. If the wind had not suddenly changed, his entire group would have met almost certain death. Soon thereafter, he found that his island headquarters in a church had been destroyed and that the parishioners, who had fled there for safety, were burned to death with the padre. At that time he commented that it wasn't time for his knell to toll. He was the first newspaper photographer on the scene and the last to leave.



Mr. Henry, a photographer by profession, was widely known in the astronomical world. Photo by C. W. Elmer.

Astronomy was his avocation and occupied almost as much of his attention as his profession. His star observation meetings, held weekly on the roof of the Brooklyn Institute, were exceedingly popular and were attended by thousands. When skies were clouded, he would conduct the meetings indoors with charts, drawings, and textbooks.

A church member of highest standing, a commercial photographer of exceptional merit, an amateur astronomer of more than national eminence, William Henry will be missed by his many associates and countless friends.

C. W. Elmer
Glenbrook, Conn.

THIS MONTH'S MEETINGS

Chicago: Members of the Burnham Astronomical Society will meet in the lobby of the Adler Planetarium at 8 o'clock, Tuesday, June 8th, to be guests of the planetarium. Mr. Wagner Schlesinger, director, will provide special demonstrations during the evening.

Cleveland: On June 11th, in the Warner and Swasey Observatory, Dr. Roy K. Marshall, Fels Planetarium, will lecture on "Great Moments in Astronomy." The meeting of the Cleveland Astronomical Society will start at 8:00 p.m.

Indianapolis: The Link Observatory will have open house for members of the Indiana Astronomical Society on June 6th. Victor Maier and Dr. Goethe Link will speak on the work of the observatory.

Kalamazoo: Spencer Van Valkenburg will speak on "The Early History of Astronomy" at 8 o'clock, June 12th, at the home of Mr. and Mrs. James Sigler, 211 Seydelle Ave., for members of the Kalamazoo Amateur Astronomical Association.

Los Angeles: "Some Famous Observatories, Past and Present," will be the topic of Miss Elizabeth Conner, librarian of the Mount Wilson Observatory, at the June 8th meeting of the Los Angeles Astronomical Society. The meeting will start at 8 o'clock in the Griffith Observatory.

Madison: The Madison Astronomical Society will hold its annual picnic and election of officers on Wednesday, June 9th. Washburn Observatory is headquarters of the society.

Pittsburgh: Election of officers and the regular business session will take place at the June 11th meeting of the Amateur Astronomers Association of Pittsburgh, in the lecture hall of the Buhl Planetarium. Two sound motion pictures will be shown, "Let's See" and "Latitude and Longitude." Activities begin promptly at 8:15 p.m.

San Diego: A membership evening is planned for the June 4th meeting of the San Diego Astronomical Society, at 7:30 p.m. in Room 405 of the Gas and Electric building. Various members will speak.

Washington, D. C.: On June 5th, at 8 o'clock in the National Museum, the National Capital Astronomers will hear Dr. John K. O'Keefe, Chief, Research Analysis Branch, Geodetic Division, Army Map Service, lecture on the function of the Army Map Service in the planning of eclipse expeditions.

KODACHROME SLIDES AVAILABLE TO AMATEURS

It was our privilege here in Santa Ana, Calif., to watch and take pictures of the caravan that moved the 200-inch mirror from Pasadena to Palomar Mountain. The sight of the immense crate containing the mirror and the California State Patrol safeguarding the valuable package so carefully was one we will long remember.

Four excellent 35-mm. Kodachrome slides of the event were taken and we would be most happy to send any interested amateurs copies at cost, 20¢ each. Prints may be made which will cost 65¢ each.

D. C. PUGH
R. #1, Box 503, Orange, Calif.

NEWS NOTES

By Dorrit Hoffleit

HALLEY LECTURE

Dr. Fritz Zwicky, California Institute of Technology physicist (who would prefer to be called a "morphologist"), gave on May 12th the first Halley lecture in England since the beginning of the war. The invitation to give this lecture is considered one of the greatest honors in astronomy. The lectureship was founded at Oxford University in 1910, the year of the most recent appearance of Halley's comet. Previous Halley lecturers from the United States have been the late W. W. Campbell, Edwin P. Hubble, Henry Norris Russell, and Harlow Shapley.

The current speaker's topic was "Morphological Astronomy," dealing with the material contents and laws of the universe, and the development of methods and planning modes of attack upon astronomical problems. Dr. Zwicky is especially well known for his work on supernovae, as well as on the dynamics of clusters of galaxies. As an outgrowth of wartime projects, he is also an authority on rockets and jet propulsion; while at Oxford, he will deliver another lecture, "The Morphology of Jet Propulsion."

ALFRED C. LANE

Alfred C. Lane (1863-1948), professor of geology at Tufts College until his retirement in protest against the "teachers oath law" in 1936, was a man of exceptional ability and wide interests. He was very active in the astronomical circles of his community, where he did much to stimulate inter-science co-operation. Professor Lane was particularly well known for his studies of the age of the earth. At one time he was head of the National Research Council's committee on the measurement of geological time by atomic disintegration. In the years since the atomic bomb, he has been referred to as the "forgotten man" of atomic research, who foretold the vast power possible in the destruction of atoms, and 22 years ago inaugurated a plan for the international exchange of scientific information on this subject.

BIBLIOGRAPHY OF GLOBULAR CLUSTERS

We call to the attention of anyone interested in clusters "A Bibliography of Individual Globular Clusters," published by Helen B. Sawyer in the *Publications* of the David Dunlap Observatory. The compiler's intention was, of course, to make the bibliography complete for all research published on individual globular clusters. But she confesses the possibility of human oversight and invites additions and corrections. She has studied more than 800 references, going back to the time of Hevelius and Halley. The bibliography should be essentially complete through 1938; thereafter the war-disruption of the distribution of astronomical literature may still be responsible for omissions.

A table is included of data on the 99 globular clusters known in our galaxy. Clusters in external systems are not included in the bibliography. Concerning the discoverers of these globulars, William Herschel is credited with finding 33, James Dunlop with 21, Messier with 14, Méchain and John Herschel with five each, and Lacaille with four. Fourteen other observers found the remaining 17 clusters.

MOUNT WILSON REPORT

The annual report of Mount Wilson Observatory is usually fairly indicative of progress in astronomy, and the past year is no exception. Here we mention but a few of the solar, galactic, and extragalactic studies which are reported. Sunspot work was carried out in collaboration with numerous other institutions. The spectra of solar flares have been studied with the 75-foot spectrograph and 212 lines identified as arising from 17 neutral and singly ionized atoms. One solar prominence was found to reach an unprecedented elevation of 1,703,000 kilometers (1.22 solar diameters) above the sun's surface.

In stellar spectroscopy, new radial velocities have been obtained for 1,000 stars and spectra for another 750. A card catalogue was prepared for all known radial velocities, containing 11,750 entries. Dr. Alfred H. Joy published radial velocities for 180 dwarfs of large proper motion, including 21 subdwarfs whose mean radial velocity is 121 kilometers per second.

In special projects, Dr. H. W. Babcock is continuing his important work on the magnetic fields in stars. Dr. A. E. Whitford determined the diameters of three stars from observations of lunar occultations; this method is applicable to angular diameters that range from 0.002 to 0.020 seconds of arc.

Dr. Joel Stebbins and Dr. Whitford established photoelectric magnitudes for 150 external galaxies, and colors for 75 such objects. In a multicolor survey of the Andromeda galaxy, Dr. W. Baade found an emission nebulosity 114 minutes of arc from the nucleus, the farthest yet discovered. It has a differential velocity of rotation in the system (Keplerian motion) of −497 kilometers per second, indicating that the mass of the spiral is 1.0×10^{11} suns.

Cancer a Lobster for th

By Dorothea Havens Chappe

SAMUEL G. BARTON, in the 15th paragraph of his article in *Sky and Telescope,* September, 1947, about Albrecht Dürer's sky maps, notes that "Cancer is represented as a lobster, whereas in Bayer's separate drawing it is a crab." The shifting of the symbol for this fourth sign of the zodiac has been the subject for genial discussion, especially during the last few years, and it is interesting to trace the sidewise gait of this crab through astronomical history to see if, to be more "scholarly," it should assume the form of a lobster. There has been almost a fashion just recently of using the lobster. Popular Christmas cards have appeared wreathed with the zodiac, showing a lobster for Cancer; a pictorial magazine used one such as its subscription gift card. Perhaps the loveliest of all the lobsters in current appearance is that etched on a broad glass plate, exquisite work of the Steuben Glass Company, whose designs and quality of manufacture are a special pride of American art. For mere convenience the crab is surely the better symbol, because it takes a rather careful drawing to differentiate a lobster from the scorpion, the sign of the zodiac about a third farther around the circle.

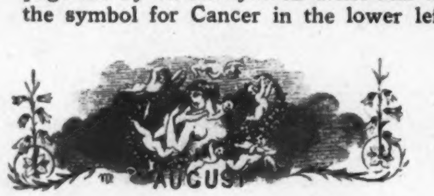
Some authorities state the lobster symbol to be 17th century, used by Bartschius and Lubienitzki (as given in that so-detailed work by R. H. Allen, *Star Names and Their Meanings,* page 109). Lubienitzki added a small shrimplike object toward Gemini, and called it Cancer Minor. Maps thereafter, especially celestial globes, sometimes used the lobster. As may be noted from the sets of charts with Dr. Barton's article, however, and in what follows here, the lobster does appear previous to that time. It is used on Schöner's globe about 1533; see *Terrestrial and Celestial Globes,* E. L. Stevenson, Vol. I, Fig. 54a. The gores of Francois de Mongenet show the lobster, in the year 1552 (Stevenson, Fig. 64); and a globe by Tycho Brahe, the "globus magnus," uses it about the year 1584. The Stevenson work, from the Yale University Press (1921), shows in Fig. 89 a fat lobster on the Jodocus Hondius globe dated 1600. One of the Dürer drawings, which as Dr. Barton says have been too seldom reproduced, is on page 28, Fig. 46 of Stevenson's work.

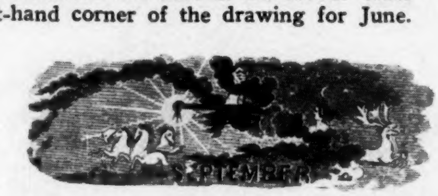
Among the crabs, Fig. 136 in Stevenson shows anonymous terrestrial globe gores of 1550 bordered with signs of the zodiac. Halley's planisphere, dedicated to King Charles II, has a nice bumpy — almost warty — crab (see Basil Brown's *Astronomical Atlases, Maps and Charts,* Plate IV, page 37). This was published originally about 1675. An out-and-out lobster in the Brown volume is that of Hevelius, Plate VII, opposite page 44. But a nice round crab is on the globe of Willem Janez Blaen, 1640 (Stevenson, Fig. 98b); and Brown dignifies as a frontispiece the early Roman MS Planisphere of Geruvigus, said to have influenced modern constellation figures. In this, Cancer is a crab. Brown's page 14 gives a 1536 drawing by Peter Apian believed to be a woodcut, from which he taught astronomy 400 years ago. The crab here is a trifle long.

Cancer, the Crab, however, reaches back beyond all these globes and drawings, in the literature of antiquity, and even in sculpture, the famous Farnese statue having a well-shaped crab in bas-relief on the globe, its claws almost under the modeled fingers of Atlas' right

Cancer is definitely a crab in Flamsteed's "Atlas Coelestis," published in 1729, from which part of the fourth chart is reproduced here.

The small pictures of the zodiacal constellations that make the borders of this page are by an anonymous artist and were made some time in the 1860's. Note the symbol for Cancer in the lower left-hand corner of the drawing for June.





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hand (Brown, Plate XIX). Some date this statue as early as 200 B.C., others say "before 73 B.C." The Egyptians in 2000 B.C. used the beetle for this constellation, their scarab, so revered Scarabaeus, symbol of immortality. The Persians, Turks, Chaldeans, Hebrews, and Arabians, all called the constellation words meaning Crab (Allen, page 108). About the year 1000 a Saxon chronicle says "Cancer that is Crabba." In the 12th century it occurs as a water beetle, and in 1489 in the *Albumasar* as a crayfish. Many Roman authors had called it Nepa, and today *nepa cinerea* is an English insect called the water-scorpion, indicating the mixture in the history of these words.

Cancer, the word itself, means crab, and its word history substantiates the crab symbol for the constellation. The use of the word to denote the disease cancer (carcinoma) is said to have come from the swollen veins around the tumor, looking like the legs of a crab. The name Cancer was early given to the fourth sign of the zodiac because of the slower north-south motion of the sun and planets when apparently in that part of the sky, the variations suggesting to the ancients the slow and sidewise walk of the crab. Other early symbols had similar characteristics of slowness, the turtle for example.

Those upholding the lobster tradition for Cancer can say "oyez, oyez," for Skeat's *Etymological Dictionary* traces the legal *oyez* from the word lobster. This is Latin, and French, and meant bony, from the shell, *ostreum*. Ostracize is a word that sprang from the old custom of writing on a shell or a potsherd when wanting to banish someone. The Middle English *lopstere*, or *loppester*, or the earlier purer form *lopust*, came to be a corruption of *locusta*, and in 1715 meant a fish like a lobster called a "long oister," and also meant the winged insect, locust. The Germans call Cancer *der Krebs*; in French it is *le Cancre*, or *l'Ecrevisse*. The Italian has *Il Cancro*, or *Il Granchio*. *Carcinus* is the Latin, of Greek derivation.

The zodiac is probably Babylonian in origin. The 12 signs of the zodiac are the 30-degree divisions of the zone apparently traveled by our sun and the planets. As associated with the constellations named for them, they are shifting, due to precession. Since the era of Hipparchus the signs have progressed to overlap now, Aries being in an area previously occupied by Pisces, and so forth. Although the sign of Cancer is usually associated with the period of the calendar June 22nd to July 20th, the sun actually does not cross the boundary between Gemini and Cancer until the latter date this year. It will be a matter of some 25,800 years for the zodiac to complete the cycle. But the signs are woven into centuries of literature and art, with a wide variance of meaning and mystic associations, including quite a bit of seasonal meteorology. For example, Doctor Johnson in *Rasselas* refers to the hot-weather "fervours of the crab."

W. T. Olcott, in *Star Lore of All Ages*, page 91, mentions that Alpha Cancri was known to the Arabs as *Acubens*, meaning the "claws"; the star marks the crab's southern claw. Zeta Cancri is a triple star of extra interest, likely with a fourth invisible companion. The two closer stars of this multiple have a period of 60 years for their orbital revolution, and the third star (about five seconds of arc distant) possibly requires more than 1,000 years to revolve around the close pair. Zeta Cancri's position is R. A. $8^h\ 9^m.3$, Dec. $+17°\ 48'$ (1950). The three stars of this system differ little in brightness: they are given as of magnitudes 5.0, 5.7, and 5.5 by Aitken; Harvard photometry makes them 5.56, 6.02, and 6.26. Zeta Cancri was discovered to be double by Tobias Mayer in 1756, and the duplicity of the principal star of that pair was discovered by W. Herschel in 1781. Burnham states that the close pair has been determined as accurately as or more accurately than any other double. This star is Aitken 6650, Burnham 4477, and Struve 1196. The *Bonner Durchmusterung* number is BD +18°1867. It was neglected until about 1825, and after that closely observed by many astronomers. Otto Struve mentioned the irregularity in the apparent motions of this system, in Volume IX of the *Poulkovo Observations*, and Seeliger published a careful study of an invisible fourth companion (to the distant star of the visible three) thought to account for the irregularity. Struve on page 232 of his measures told of Burnham discarding this supposition as insufficient. Burnham does state the evidence to be "wholly insufficient," but W. Struve cited the then recent actual discovery of satellites for Sirius and Procyon, arguing for more credence in regard to Seeliger's work, saying it "appears to me perfectly just." Files bulge with interesting current work on this system.

A crab appears elsewhere in our sky, but on quite a different beach from the Cancer of this discussion. The nebula in Taurus is named crab from its close round shape. So far no one has wanted to call it a lobster. As it may be the result of the Chinese supernova of 1054, the Crab nebula is of especial interest now in the discussion of novae and supernovae, and in theories of the origin of the solar system.

The cryptic symbols for the zodiacal figures are handy. The one for Cancer certainly suggests a crab more than it does a lobster. Or are these twinlike circles representing the Aselli? Old eastern zodiacs used the figure of two asses within the constellation Cancer, near the cluster Praesepe. This star cluster was known in English folklore as the Beehive. It is the group of stars that showed Galileo that many stars invisible to the naked eye could be found with the telescope.

A list of zodiacal animals portrayed by the Chinese (Brown, page 62) contains no crab, or lobster, and in fact no scorpion. One of the Chinese names for Cancer was the "red bird." The Hindu name (Olcott, page 90) was *pushya*, meaning flower. Flower also was Peruvian — their sacred flower called *cantut pata*. This similarity of symbolism has been quoted by some historians as perhaps showing communication between these widely separated peoples. The constellation was honored in Yucatan, where Cancer was made the subject of dedication for a temple.

Certainly in the Dürer maps the Cancer lobster and the Scorpion look much alike, same number of legs, and jointed tails, with more condensed sections in the drawing of the lobster. Dürer's figures all around the zodiac are so

(Continued on page 207)

BOOKS AND THE SKY

STAR STORIES

Gertrude C. Warner. The Pilgrim Press, 1947, Boston, Mass. 64 pages. $1.25.

THE CURIOSITY and the ever-challenging interest of the child in his surroundings is amazing. To the child, the world is filled with wonders: the earth, people, plants, the sky. Even the youngster's interest in the stars is aroused. **Star Stories** is just the book to read when a boy or girl first becomes interested in the stars.

In **Star Stories,** whose title could be more descriptively stated as Judy's experiences with her friends the stars, we find descriptions of 19 constellations, directions for finding them, and a little about recognizing the major planets. The directions for locating these constellations, a fairly representative group, are clearly stated, and the time of year when they are in the eastern part of the sky given.

This book is made to appeal to children, and it does. It is of small size, and the illustrations are numerous and simple. For each of the constellations there is a chart, realistically drawn with white stars on a blue background. At the bottom of the page is a section with a small illustration appropriate to the time of year, and with a space for the child to write the date on which he found and identified the constellation in the sky. This, in addition to a certificate on the last page which certifies that he has learned the 19 constellations and four planets, provides an incentive to the young stargazer.

The constellations are represented as they look in the sky with a few lines to help the child learn to recognize them. No elaborate drawings of the figures represented by the constellations are included, a practice which I heartily approve, since such fanciful designs confuse the beginner.

The story of Judy and Dr. Lorry, her friend and teacher, which runs through the book gives continuity and adds interest and friendliness to what could be just a dry, factual treatise. Dr. Lorry tells some of the interesting facts about the bright stars, but there is nothing about the mythology connected with the constellations. To include these myths, of which there are many interesting ones, would make the book more complete, perhaps, but would detract from its usefulness as a first book on the stars.

CECILE T. WEAVER
Mt. Hamilton, Calif.

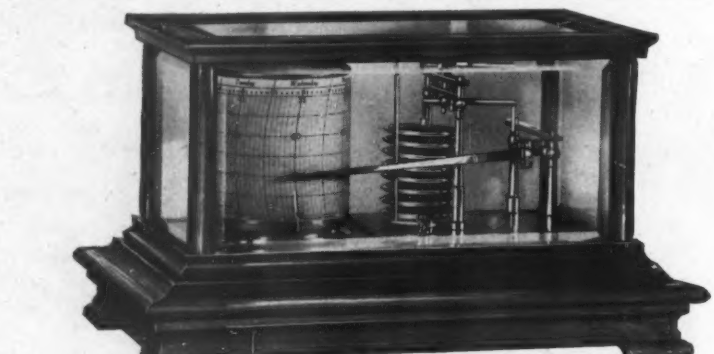
ATLAS DER STERNBILDER

Oswald Thomas. Verlag "Das Berglund-Buch," Salzburg, 1945. 155 pages. No price available.

AN ATLAS with simple constellation charts by a well-known German astronomer may be of interest to those who would like to combine a study of German and astronomy. The few pages of introductory text material, and the discussion of individual constellations which appears at the back of the book, as well as the descriptions included in the catalogue of objects by constellation, are all in German.

The star maps progress from elementary to more complicated. A series of charts is made up of a pair for each month, one with white stars and blue mythological outlines against a black background, the facing chart, in black on white, with constellation names (in German) and geometrical outlines of the constellations. There follows a series of 32 pairs of charts, each grouping a few constellations in which considerable detail is shown.

The catalogue gives by constellation



information on stars, position, description of position (for instance, Gamma Cassiopeiae, "der mittlere im grossen W, am Knie"), magnitude, spectrum, distance, name, and any note of interest on color, separation of doubles, and so on.

With the aid of the German-Latin and Latin-German lists given, and the bilingual index, even the non-German-speaking person should have no great difficulty finding his way around the charts. H. S. F.

ATOMICS FOR THE MILLIONS

M. L. Eidinoff and **H. Ruchlis.** Whittlesey House, New York, 1947. 281 pages. $3.50.

A MYTH has been growing for the last few years that a physicist's training so poorly equips him to explain the fundamentals of his science to the general public that one naturally expects to see popular books on modern physics written by professional journalists. **Atomics for the Millions** completely explodes this myth. Dr. Eidinoff and Mr. Ruchlis, both of whom are professional scientists, have produced a really outstanding piece of scientific journalism in interpreting the workings of nuclear physics to the non-technical reader.

Their book, with its amusing illustrations, first traces the historical development of the atomic theory and explains the fundamentals necessary to the understanding of the atomic nucleus. This discussion occupies the first half of the book. The next 80 pages describe the physics of the fission process and the atomic bomb.

The last quarter of the book is a section entitled "Your Atomic Age," in which the authors discuss the benefits which mankind may enjoy if the results of the tremendous research and development which have been carried out in nuclear physics are put to their obvious peacetime applications. So much has been written recently about the terrible implications of atomic warfare that the public has a tendency to regard nuclear fission as synonymous with atomic bombs, destruction, and frightful conflict. An excellent antidote for this point of view is to be found in this authoritative discussion of the benefits which may and should be derived from the peacetime uses of atomic energy.

The tone and style of the writing are excellent. One can see in its careful and lucid explanations long experience of teaching physics at the high-school level. The book is easy to read and completely authoritative, and really should accomplish what the authors must hope by the title — bringing atomics to the millions.

Both the jacket and the advertisements feature an introduction by Dr. Harold Urey. This implicit stamp of approval by one of the Nobel laureates who worked on the Manhattan Project serves its purpose of giving the reader a feeling that the volume should be outstanding, although the actual introduction, which is but a page, adds nothing materially to the book.

This is a book one would like to keep, and for this reason it is unfortunate that the present edition is printed on paper of such poor quality that it is doubtful if it would last as a permanent volume in one's library.

SANBORN C. BROWN
Massachusetts Institute of Technology

CANCER A LOBSTER FOR THE NONCE

(Continued from page 205)

charming, it sets one wishing for a nice fat crab here near the lion's mouth. Where else is so lovely a winged Virgo! And where else does the tail of Leo so engagingly curl! Albrecht Dürer, third of a Hungarian family of 18 children, German painter and engraver, was a foremost artist. Yet Mekanchon said of him, "His least merit was his art." (*New International Encyclopedia,* page 540.) The big A astride the little D with which he signed his work was a standard architecturally and in other fields of that period. He enjoyed details — would likely have been intrigued by this lobster-crab discussion.

In any so exact a science as astronomy, its mere symbolism seems indeed a slight matter. Many of its subjects and facets allow of no such leniency or choice. It is a case of serious conscience in observing or measuring, or even theorizing, not to try to "pull" results, but in this so unimportant a matter as crab versus lobster on the zodiacal menu, sides can be genially taken, not only to pull, but for a regular "pull away," like the child's game of London Bridge. Caught in that march, and taken aside, the whisper is: "Which do you choose for the pull away, Lobster or Crab?"

Planetarium Notes

ADLER PLANETARIUM

900 E. Achsah Bond Drive, Chicago 5, Ill. Wabash 1428

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturers:* Harry S. Everett, Albert B. Shatzel.

June: STORY OF THE CALENDAR. We learn how the many types of calendars of past and present were formed by combining units of time derived from various celestial motions.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa. Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

June: THE MOON IN JUNE. The story of the nearest of heavenly bodies, the physical conditions on the moon, its mountains and craters, the mechanism of eclipses, will be discussed.

July: THE END OF THE WORLD.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

June: LIFE ON OTHER WORLDS. The conditions existing on other planets will be described, from the best knowledge of astronomers, and the possibility of life of some kind, under these conditions, will be evaluated.

July: SUNSPOTS AND NORTHERN LIGHTS.

GRIFFITH PLANETARIUM

P. O. Box 9787, Los Feliz Station, Los Angeles 27, Cal., Olympia 1191

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

June: UNDER THE SOUTHERN CROSS. This show takes the audience to the Southern Hemisphere. Different constellations and stars will be pointed out, and the classical outlines will appear among them.

July: BRIGHT COLORS IN THE SKY.

HAYDEN PLANETARIUM

81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale.

June: COLOR IN THE SKY. The sky panorama is like a moving picture in technicolor. The secret of the rainbow, lunar halos, and the range of color in the stars is explained in this show.

July: TRIP TO THE MOON.

GLEANINGS FOR A. T. M.s

THE COMPOUND REFLECTING TELESCOPE — II

By Allyn J. Thompson

Another combination of conic curves has lately received notice among amateurs. It consists of an ellipsoidal primary mirror and a spherical secondary. The favorable qualities of this combination, such as its relative simplicity of manufacture, were recognized and advocated some years ago by Dall, who made several telescopes of that design. A few years later, Alan R. Kirkham published formulas for computing the aberration of the spherical secondary (**Scientific American**, June, 1938) as well as the amount of compensatory undercorrection (percentage of r^2/R) to be accorded the primary mirror. Kirkham's formulas were later combined by George P. Arnold into a more convenient form, given below. (See also **Sky and Telescope**, August and November, 1946.)

Undercorrection is the condition present when parallel rays of light, incident on the edge zones of a concave mirror, are brought to a focus at a point on the axis

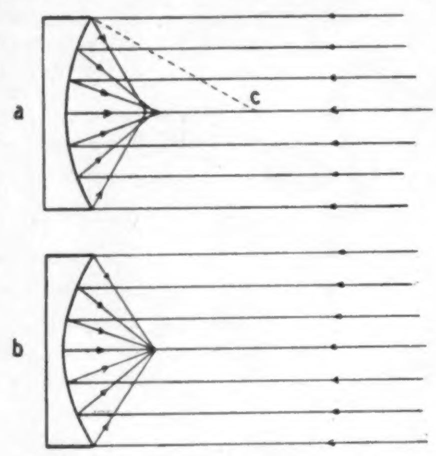


Fig. 5. Paths of reflected parallel rays from: a, spherical mirror; b, paraboloidal mirror. Center of curvature of the spherical mirror is at C.

that is nearer to the vertex of the mirror than are the focal points for similar rays incident on the mirror's inner zones. In this sense, as shown in Fig. 5, an ordinary spherical mirror is undercorrected, and it is to overcome this defect that a telescope mirror is figured as a parabola. Fig. 5b shows how the parabola brings all the axial rays to the same focus on the axis. With overcorrection, the parabola has been deepened to a hyperbola and the edge rays focus farther out than the central rays. Either undercorrection or overcorrection may be regarded as a longitudinal or axial aberration, and if it exceeds a certain tolerable amount will produce blurring in the image.

The reason for undercorrecting the primary mirror when using a spherical secondary can be deduced from a comparison of Figs. 6 and 7. In both of these diagrams the secondary mirror is assumed to have a spherical figure. In Fig. 6, the primary is a paraboloid which would focus all rays to the primary focus **F** were they not interrupted by the secondary. The effect of the aberration of the latter is to cause edge-zone ray **B** to come to a focus at **b** farther to the left than does ray **A** from the center zone — this is described as overcorrection.

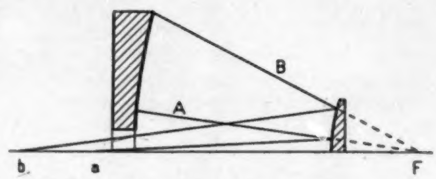


Fig. 6. A paraboloidal primary has its perfect correction destroyed by the spherical secondary.

In Fig. 7, the primary mirror is more nearly spherical, that is, it is undercorrected, so that, in the absence of the secondary, ray **B** focuses nearer the vertex than ray **A.** But this condition is compensated by the aberration of the secondary when it is introduced, and the final focus of all rays parallel to the axis is at **f'**, where we want it to be. In this diagram the distance **ba** represents the longitudinal spherical aberration which must remain in the primary mirror.

Arnold's formula for computing the amount of correction to be given to the primary is

$$\mathbf{N} = 1 - \frac{4\mathbf{p}^2}{\mathbf{RR'}}\left(\frac{\mathbf{p' + p}}{\mathbf{p'}}\right)^2 \qquad (1)$$

where **N** is the percentage of $\mathbf{r^2/R}$ for any zone, **R** the radius of curvature of the primary, **R'** the radius of curvature of the secondary, and **p** and **p'** have the meaning shown in Fig. 3. All quantities in the above equation are to be considered positive. Percentages of correction, according to Kirkham, vary between 70 and 90 per cent of $\mathbf{r^2/R}$, depending on the design of the telescope. The figure of the primary mirror when so constructed approximates that of an ellipsoid.

The above formula, however, accounts only for the primary spherical aberration

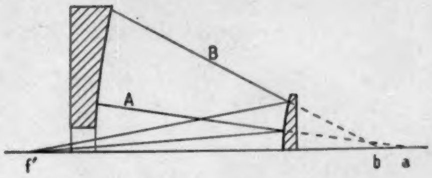


Fig. 7. The primary is undercorrected in order to compensate the overcorrection of the spherical secondary.

of the secondary mirror, therefore a small residual aberration will still be present in the telescope. But the additional correction that would have to be given to the primary mirror in order to achieve total compensation is probably too small to be measured with certainty by means of the Foucault test; at any rate the residual aberration should lie within tolerances to be given later.

Coma is not as well balanced out in this system as it is in Cassegrain's, but within a field of view of the size that will ordinarily be used, it may be regarded as being practically negligible.

Albert G. Ingalls, editor of **ATM** and **ATMA**, has proposed the name "Dall-Kirkham" for this telescope, as a merited and more dignified one than the misnomer "modified Cass." With this suggestion the author is in accord, and in any further discussion here the system will be so designated.

Of a third geometric combination, the spherical primary mirror and oblate-spheroidal secondary, little has been found in print, a surprising circumstance, since the mirror shapes suggest an ease in figuring not found in either of the first two combinations described. This proved to be the case, as I learned in making such a telescope, which for the sake of brevity

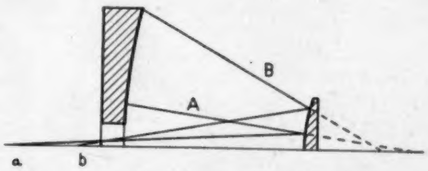


Fig. 8. With both primary and secondary spherical, the final image is undercorrected.

in reference was christened the "spheroblate." In Fig. 8 both mirrors are assumed to be spherical. Since the positive aberration of the primary (which can be roughly approximated from the formula, $r^2/4R$) overpowers the negative aberration of the secondary, undercorrection shows up in the final image. The cure is obvious — either the primary mirror must be deepened into an ellipsoid of proper eccentricity, giving us the Dall-Kirkham telescope, or the secondary must be overcorrected or flattened at the center, thus converting its figure into an oblate spheroid. The latter course is the one that should be followed in producing the spheroblate telescope, and this combination should yield a perfectly defined axial image.

Unfortunately, the coma in this tele-

scope is very serious, about equal to that of a paraboloidal mirror of the same focal ratio as the primary, as the author found by actual celestial observations. It is useless therefore to attempt to make a spherical primary of the low focal ratio ordinarily required for a compound telescope.

A spheroblate which apparently contained little or no coma was described in the December, 1947, issue of the **Journal** of the British Astronomical Association. However, this instrument was designed for high-power planetary observation; it has an f/8 primary and an equivalent focal ratio of f/56. The field of view of such a high-powered instrument is so small that it will cover only a few minutes of arc, and for a field of this size there is practically no coma in an f/8 mirror.

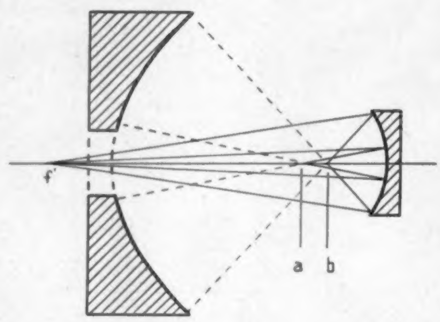


Fig. 9. A modified Gregorian system, in which the primary is hyperboloidal and the secondary spherical.

The Gregorian. The image formation in this telescope has already been described (Fig. 1). Production of an ellipsoidal figure on the surface of the small secondary is not an easy task, besides entailing the construction of special equipment for testing. It might, therefore, be a simpler matter to retain a spherical figure on the secondary, and to make all of the correction on the primary. The situation would be about as shown in Fig. 9. Light rays emanating from a point **f'** on the axis and incident on the central and edge zones of a concave spherical mirror of suitable radius will be reflected to foci at **a** and **b** respectively. The distance **ab** represents the undercorrection of the spherical secondary. Therefore, it is only necessary to overcorrect or "hyperbolize" the primary mirror by whatever amount (usually not more than a few hundredths of an inch) is required to compensate the undercorrection of the secondary.

Testing Methods. The possibility of accomplishing in the workshop the desired correction in each compound telescope combination will be discussed by us from a practical standpoint, keeping in mind the fallibilities and infirmities of the amateur optician. After learning what awaits him, he may then either abandon the project or (it is hoped) tackle the method that offers the best chance — or the greatest challenge — of success.

It has been pointed out that if the primary mirror is truly a paraboloid, and the secondary a true hyperboloid, the system will be perfectly corrected for axial images and will give maximum correction for coma. In the application of the Foucault test at the center of curvature, production of the paraboloidal figure

on the primary mirror is limited partly by the worker's ability to interpret shadow appearances correctly and partly by limitations of the test itself. While the Fou-

TABLE I

TOLERABLE TOTAL LONGITUDINAL ABERRATION IN TELESCOPES

Focal ratio	Error in inches	Focal ratio	Error in inches
12	0.025	22	0.085
13	0.030	23	0.093
14	0.035	24	0.101
15	0.040	25	0.110
16	0.045	26	0.119
17	0.051	27	0.128
18	0.057	28	0.138
19	0.063	29	0.148
20	0.070	30	0.160
21	0.078		

cault test may possess the required delicacy in sufficiently skilled hands, errors of the order of 0.02" in the measured correction are likely to elude the average observer on mirrors of almost any proportion.

Since the aberration at the primary focus of a mirror amounts to one quarter the error in correction at the knife-edge (with a stationary pinhole), a mirror differing by 0.02" more or less than the value of r^2/R will have a longitudinal aberration at prime focus of 0.005". What this will amount to at the secondary focus of the compound reflector, if not cancelled out, is determined from the fact that the aberration of the primary mirror is amplified in the secondary focal plane as the square of the amplifying ratio.

For example, in the model telescope (primary ratio f/3.4, final ratio f/17, amplification 5) shortly to be designed here, an aberration of 0.005" times 5^2 is 0.125", or ⅛ of an inch!

Although from this it might appear that there is danger in high amplification, such is not the case. As can be seen from Table I, the tolerable total aberration of the telescope varies as the square of its focal ratio, and thus keeps pace with the effect of amplification. But to keep within the given tolerances, the primary mirror's correction error may not exceed the values given in Table II. While the tolerable

TABLE II

TOLERABLE KNIFE-EDGE ERROR IN TELESCOPE MIRRORS, WITH STATIONARY PINHOLE AT CENTER OF CURVATURE

Focal ratio	Error in inches	Focal ratio	Error in inches
3	0.006	7	0.035
3.5	0.008	8	0.045
4	0.011	9	0.057
4.5	0.014	10	0.070
5	0.018	11	0.085
6	0.025	12	0.101

knife-edge error given here is more liberal with higher focal ratios, practical construction will restrict the mirror's proportions to about f/5, so there is no escaping the fact that a more rigorous test than is ordinarily possible at the center of curvature is desired. An improved method of testing, devised by the author, that will enable amateurs to measure mirror corrections with great precision will be described later.

(To be continued)

OBSERVER'S PAGE

Greenwich civil time is used unless otherwise noted.

OBSERVATIONS OF MARS

The view of Mars I had with the 18½-inch refractor of Dearborn Observatory on the evening of March 19th, at 7:00 p.m. CST, was quite the best I have ever had. The combination of good seeing and a favorable portion of the Martian surface made it a rare event. The Syrtis Major was just about central on the disk, as the enclosed drawing shows; the Thoth canal was extremely prominent, and a number of others were glimpsed but not steadily held. The appearance of the disk was much as Pickering drew it on his map of 1926 in **Popular Astronomy.**

The central meridian shown here is 289°; diameter of disk 12″.12; Martian date June 4th; distance from earth 71,610,000 miles. The sky was 4½ on a scale of 5, and I used 500 power. The numbered features on the drawing are: 1. Syrtis Major; 2. Libya; 3. Thoth; 4. Utopia; 5. Pyramus; 6. Ismenius Lucus; 7. Aeria; 8. Mare Hadriacum; 9. Hellas; 10. Syrtis Minor.

My observations of Mars this opposition were generally satisfying, both with my own small refractor and with the large Dearborn telescope. I saw a number of canals with the large refractor quite beyond doubt. However, they were seen more as Pickering saw them and not as Lowell depicted them, but the location of Evanston is not suited to the best observing. Details on planets are seldom sharp and crisp, certainly not as they would be if the instrument were out in Arizona.

JOHN STERNIG
1148 Chestnut St.
Deerfield, Ill.

AURORA RESPONSE

At the Northeast region meeting of the Astronomical League, C. A. Federer, Jr., vice-president of the league, reported on the need for auroral observers during the current maximum of solar activity. It is expected that as soon as societies can acquaint their members with the various programs suggested at the meeting, there will be many groups making aurora observations. Already, the Aldrich Astronomy Club, Worcester, Mass., has organized five groups of observers and has applied for forms and instructions to carry on Dr. C. W. Gartlein's program of aurora study.

Meanwhile, R. H. Thompson, of 641 S. Union St., Olean, N. Y., observed an unusual display of northern lights on March 14th. He writes: "About midnight there were gray rays reaching far into the sky; some were massed just above the horizon; and some were narrow streaks. At 2:00 a.m., March 15th, the rays began to flash rapidly in all directions in the northern half of the sky and at times reached nearly to the southern horizon. The sky was bright with stars visible all through the display, which was like none I had ever seen. Radio was out."

GREENWICH CIVIL TIME (GCT)

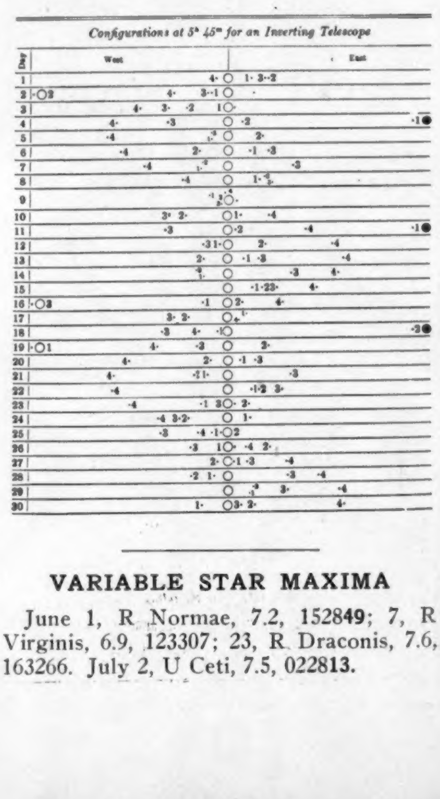
TIMES used on the Observer's Page are Greenwich civil or universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the GCT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

There are no favorable occultations this month according to the information furnished for the nine standard stations.

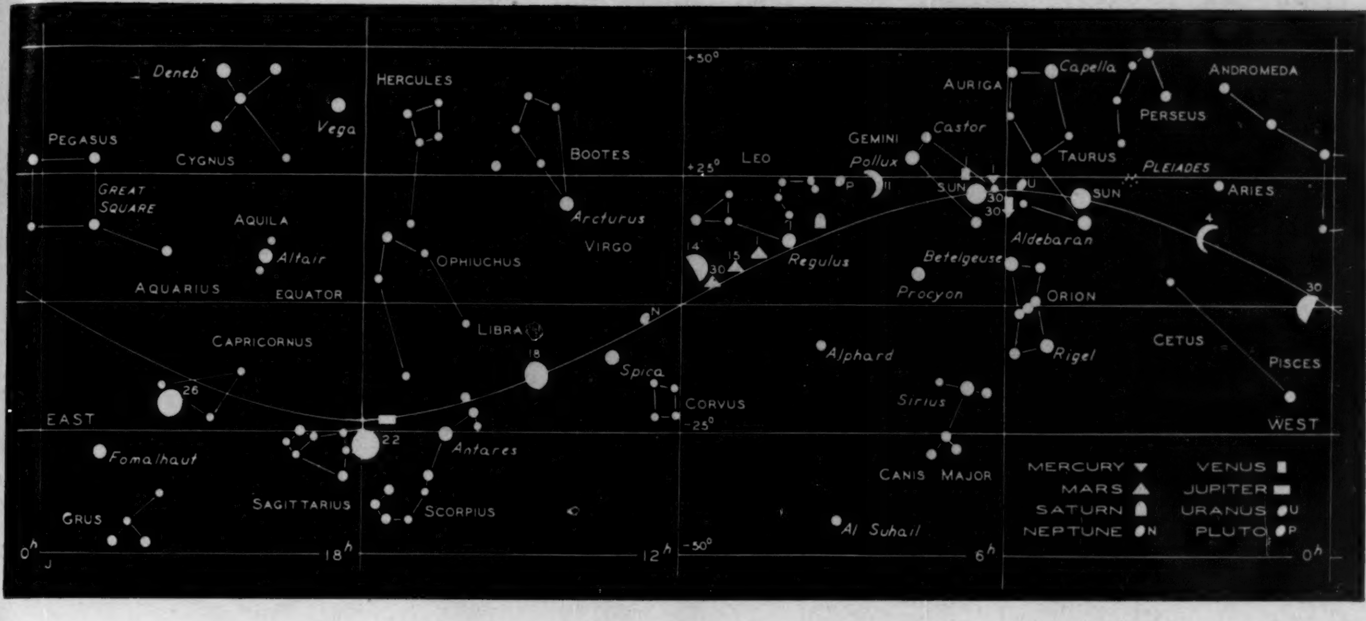
JUPITER'S SATELLITES

Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the American Ephemeris and Nautical Almanac.



VARIABLE STAR MAXIMA

June 1, R Normae, 7.2, 152849; 7, R Virginis, 6.9, 123307; 23, R Draconis, 7.6, 163266. July 2, U Ceti, 7.5, 022813.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury can easily be seen the first 10 days of June, for an hour or more after sunset. The planet then rapidly approaches the sun, with inferior conjunction on the 24th.

Venus passes from being a brilliant evening star early in June, through inferior conjunction, to be seen rising one half hour before the sun by the end of the month. Its magnitude the first week of June is −4.0, its disk 12 per cent illuminated, a crescent 46 seconds of arc in diameter. By the 14th, a four-per-cent crescent measures 55 seconds, visible in low-powered field glasses. As Venus passes south of the sun, it will be last viewed in the evening sky about the 18th or 19th. On those dates, Venus will set about 25 minutes after the sun, its magnitude −3.1; with optical aid it will show an extremely narrow crescent nearly one minute of arc across. At inferior conjunction the planet will be 2½ degrees south of the sun's center at 14:00 on the 24th, and of magnitude −2.7, when it may possibly be seen.

Earth will reach heliocentric longitude 270° on June 21st at 12:11 GCT. Summer commences in the Northern Hemisphere and winter begins south of the equator.

Mars, no longer a prominent object, sets about four hours after the sun. By June 30th, Mars is located a little over one third of the distance from Regulus to Spica, the three nearly equal in brightness.

Jupiter dominates the midnight sky, as it passes opposition on the 15th; its magnitude is −2.2. Telescopically, its disk is 44 seconds of arc in diameter.

Saturn, magnitude +0.7, is about seven degrees from Regulus. The ringed planet remains in the western sky for from four to 2½ hours after sunset.

Uranus is invisible, as conjunction with the sun occurs on June 17th.

Neptune is 1½ degrees south of Gamma Virginis. On the 15th, it is at $12^h\ 40^m.0$, −2° 37′; 8th magnitude.

NOTE: The five bright planets will be above the horizon one hour after sunset during the first week of June. Mercury and Venus will be 7° apart low in the northwest, Saturn and Mars near the meridian, and Jupiter just rising in the southeast.

E. O.

PHASES OF THE MOON

New moon	June 7, 12:55
First quarter	June 14, 5:40
Full moon	June 21, 12:54
Last quarter	June 29, 15:23
New moon	July 6, 21:09

ANNULAR ECLIPSE OBSERVED

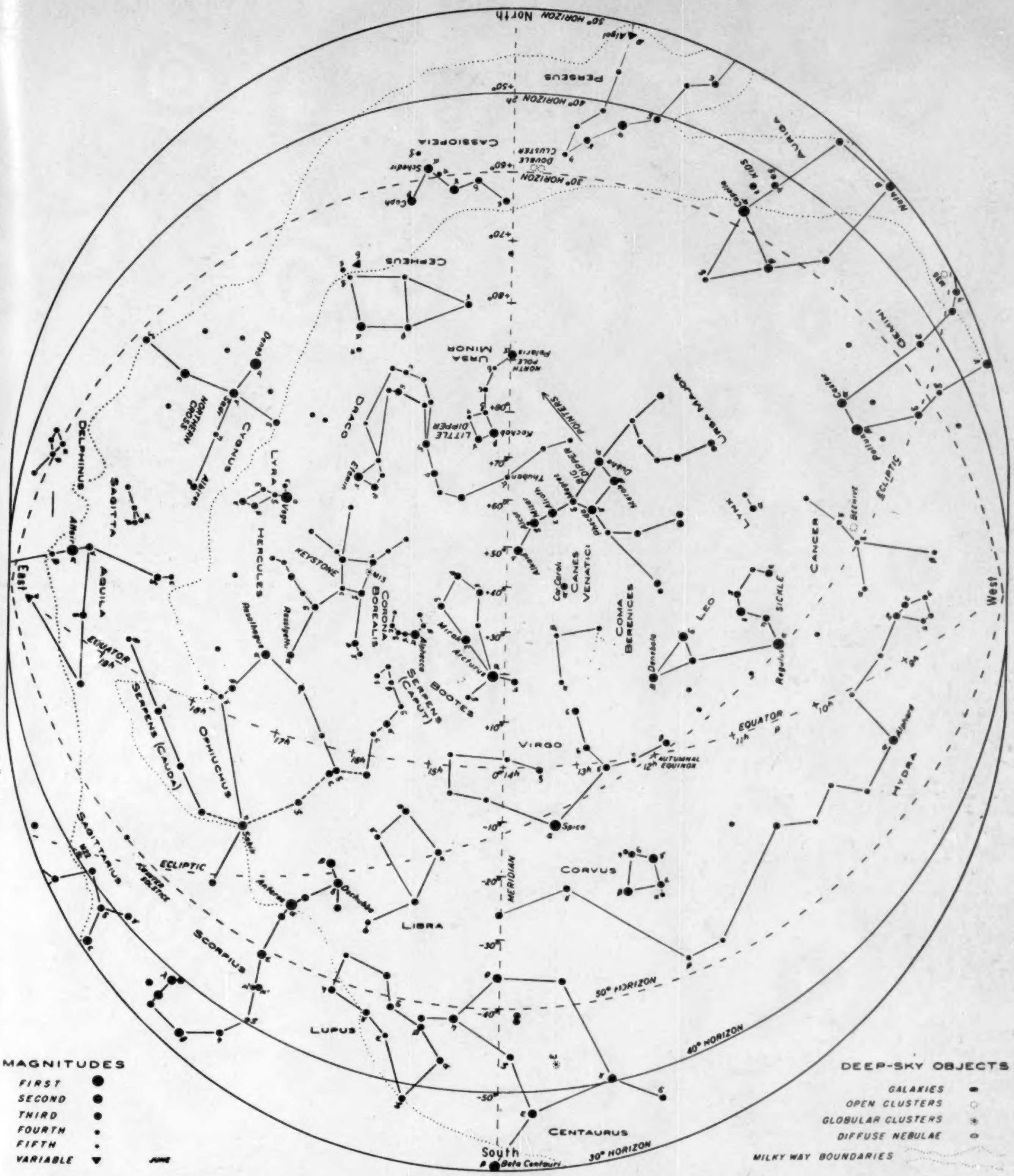
Associated Press reports published in local papers for May 10th state that the annular eclipse of the sun was hidden, presumably by clouds, for five of seven of the National Geographic's observing parties. The successful groups were at Bangkok, Siam, and at Ruben Jima, Japan. No report had been made of the results of observations from two B-29 airplanes which were to have flown above the weather in the Aleutians.

HERE AND THERE WITH AMATEURS

*Members receive *Sky and Telescope* as a privilege of membership. †Member organizations of the Astronomical League.

City	Organization	Date	P.M.	Season	Meeting Place	Communicate with
ANN ARBOR	†*Ann Arbor A.A.A.	2nd Mon.	7:30	Oct.-June	U. of Mich. Obs.	Stewart W. Taylor, 1106 Birk Ave.
ATLANTA	Atlanta Ast'mers	3rd Fri.	7:30	Sept.-June	Agnes Scott College	W. A. Calder, Agnes Scott College
BADEN, PA.	†*Beaver Co. A.A.A.	2nd Tue.	8:00	Sept.-June	Private homes	Mrs. R. T. LuCaric, Bx. 463, *Baden* 2365
BATTLE CREEK	B. C. A. A. Club	2nd Fri.	8:00	Oct.-June	Kingman Museum	Mrs. W. V. Eichenlaub, 47 Everett St.
BROOKLYN, N. Y.	Astr. Dept., B'klyn Inst.	Rd. Table 3rd Thu.	8:15	Oct.-April	Brooklyn Inst.	Brooklyn Institute
BUFFALO	*A.T.M.s & Observers	1st, 3rd Wed.	7:30	Oct.-June	Mus. of Science	R. Missert, 29 Crosby Ave., Kenmore
CAMBRIDGE	†*Bond Ast. Club	1st Thu.	8:15	Oct.-June	Harvard Obs.	Miriam Dickey, Harvard Observatory
"	†*A.T.M.s of Boston	2nd Thu.	8:00	Sept.-June	Harvard Obs.	Frank M. Roe, 35 Pemberton St. (40)
CHATTANOOGA	Barnard A. S.	2nd Fri.	8:00	Oct.-May	Jones Observatory	C. T. Jones, 302 James Bldg., *CHat.* 7-1936
CHICAGO	†*Burnham A. S.	2nd Tue.	8:00	Sept.-June	Chi. Acad. of Sciences	J. M. Showalter, 6200 Kenmore Ave.
"	Chicago A. S.	Monthly	8:00	....	Adler Planetarium	Adler Plan., *Wabash* 1428
CINCINNATI	*Cin. A. A.	2nd Fri.	8:00	Sept.-June	Cincinnati Obs.	T. R. Stoner, RR 8, Cin. 30, *BE* 7937-R
"	*Cin. A. S.	3rd Wed.	8:00	Sept.-June	5556 Raceview Ave.	A. C. Moore, 5548 Raceview Ave. (11)
CLEVELAND	Cleveland A. S.	Fri.	8:00	Sept.-June	Warner & Swasey Obs.	Virginia Burger, Warner & Swasey Obs.
COLUMBIA, S. C.	North'n Cross A.S.	Every Mon.	8:15	All year	Melton Observatory	Dr. L. V. Robinson, Univ. of S. C.
COLUMBUS, OHIO	*Columbus A. S.	Last Tue.	8:00	All year	McMillin Obs.	J. A. Hynek, Ohio State Univ.
DAYTON	A.T.M.s of Dayton	3rd Sat.	Eve.	....	Private homes	W. C. Braun, New Lebanon
DAYTONA BEACH	D. B. Stargazers	Alt. Mon.	8:00	Nov.-June	500 S. Ridgewood Ave.	Rolland E. Stevens, 500 S. Ridgewood
DETROIT	†*Detroit A. S.	2nd Sun.	3:00	Sept.-June	Wayne U., Rm. 187	E. R. Phelps, Wayne University
"	†*N. W. Detroit A.S.	1st Tue.	8:00	Sept.-June	Redford High Sch.	John W. Broxholm, 21412 Pickford
DULUTH, MINN.	†*Darling Ast. Club	1st, 3rd Fri.	8:00	All year	Darling Observatory	Mrs. Rachel Bulkley, 1317 N. 5 St., Superior, Wis., 4507
FT. WORTH	Tex. Observers	No regular meetings				Oscar E. Monnig, 1010 Morningside Dr.
GADSDEN, ALA.	Ala. A. A.	1st Thu.	7:30	All year	Ala. Power Audit.	Brent L. Harrell, 1176 *W* or 55
GENEVA, ILL.	*Fox Valley A. S.	3rd Tue.	8:00	....	Geneva City Hall	Joseph Zoda, 501 S. 6th, St. Charles
HOUSTON	*Houston A. S.	Last Fri.	7:30	All year	Mus. Nat. Hist. Annex	Mrs. Johnnye Murray, 1007 W. Gray (6)
INDIANAPOLIS	†Indiana A. S.	1st Sun.	2:15	All year	Riley Library	E. W. Johnson, 808 Peoples Bank Bldg.
JACKSONVILLE	*J. A. A. C.	1st, 3rd. Mon.	8:00	All year	Private homes	E. L. Rowland, Jr., 442 St. James Bldg.
JERSEY CITY, N. J.	†Revere Boys Club	Mon., Tue.	7:15	All year	Gregory Mem. Obs.	Enos F. Jones, 339 Wayne St.
JOLIET, ILL.	†Joliet A. S.	3rd Mon.	8:00	Oct.-May	Jol. Township H. S.	Mrs. Robert L. Price, 403 Second Ave.
KALAMAZOO	†Kalamazoo A.A.A.	Sat.	8:00	Mar.-Dec.	Private homes	Mrs. G. Negrevski, 2218 Amherst, 31482
KEY WEST, FLA.	†Key West Ast. Club	1st Wed.	8:00	All year	Private homes	W. M. Whitley, 1307 Div. St., 724-R
LOS ANGELES	L.A.A.S.	2nd Tue.	7:45	....	Griffith Obs.	H. L. Freeman, 853½ W. 57 St.
LOUISVILLE, KY.	†L'ville A. S.	1st Tue.	8:00	Sept.-May[1]	Univ. of Louisville	B. F. Kubaugh, 621 34th St.
MADISON, WIS.	†Madison A. S.	2nd Wed.	8:00	All year	Washburn Obs.	Dr. C. M. Huffer, Washburn Obs.
MEMPHIS	A.T.M.s of Mem.	Meetings suspended				R. E. Wendt, Jr., 2084 Linden Ave.
MIAMI, FLA.	South'n Cross A.S.	Every Fri.	7:30	All year	M. B. Lib. Grounds	A. P. Smith, Jr., 426 S.W. 26th Road
MILWAUKEE	†*Milw. A. S.	1st Thu.	6:15	Oct.-May[2]	City Club	E. A. Halbach, 2971 S. 52 St., W. Allis
MINNEAPOLIS	M'polis A. C.	1st, 3rd Wed.	....	....	Public Library	Mrs. A. Ljungren, 4054 Russell Ave. N. (12)
MOLINE, ILL.	†*Pop. Ast. Club	Wed.[3]	7:30	Feb.-Nov.	Sky Ridge Obs.	Carl H. Gamble, Route 1
NASHVILLE	*Barnard A. S.	2nd Thu.	7:30	All year	Vanderbilt Univ.	E. Keller, 2716 Hartford Dr. (11), 5-0766
NEW HAVEN	†New Haven A.A.S.	Last Sat.	8:00	Sept.-June	Yale Obs.	J. J. Neale, 29 Fairmont Ave.
NEW ORLEANS	A.S. of N. Orleans	Last Wed.	8:00	Sept.-May	Cunningham Obs.	Dr. J. Adair Lyon, 1210 Broadway
NEW YORK	*A.A.A.	1st Wed.	8:15	Oct.-May	Amer. Mus. Nat. Hist.	G. V. Plachy, Hayden Plan., *EN.* 2-8500
"	†Junior Ast. Club	3rd Sat.	Aft.	Oct.-May	Amer. Mus. Nat. Hist.	J. B. Rothschild, Hayden Plan., *EN.* 2-8500
NORFOLK, VA.	†*A.A.S. of Norfolk	2nd, 4th Thu.	8:00	All year	635 W. 29th St.	P. N. Anderson, 635 W. 29th St.
NORWALK, CAL.	Excelsior Tel. Club	Thu.	7:00	All year	Excelsior Union H. S.	Geo. F. Joyner, 410 Sproul St.
NORWALK, CONN.	Norwalk Ast. Soc.	Last Fri.	8:00	Sept.-June	Private houses	Mrs. A. Hamilton, 4 Union Pk., 6-5947
OAKLAND, CAL.	†*Eastbay A. A.	1st Sat.	8:00	Sept.-June	Chabot Obs.	Miss H. E. Neall, 1626 Chestnut, B'keley
OWENSBORO, KY.	†*Owensboro A. C.	3rd Sat.	8:00	All year	Public Library	Herman Batt, 1507 Hathaway St.
PALO ALTO, CAL.	†*Ast. & Tel. Club	1st Fri.	7:30	All year	Community Center	Miss D. Rossiter, 922 Roble Ave., Menlo Pk.
PHILADELPHIA	†A. A. of F. I.	3rd Fri.	8:00	All year	The Franklin Inst.	Edwin F. Bailey, *Rit.* 3050
"	*Rittenhouse A. S.	2nd Fri.	8:00	Oct.-May	Morgan Physics, U. Pa.	Sarah Lippincott, Sproul Obs., Swarthmore
PITTSBURGH	†*A.A.A. of P'burgh	2nd Fri.	8:00	Sept.-June	Buhl Planetarium	Louis E. Bier, 837 Estella St.
PONTIAC, MICH.	*Pontiac A.A.A.	2nd Thu.	8:00	All year	Private homes	Mrs. M. Chircop, 147 Prospect St., 21455
PORTLAND, ME.	†A. S. of Maine	2nd Fri.	8:00	All year	Private homes	H. M. Harris, 27 Victory Ave., S. Portland
PORTLAND, ORE.	†*Portland A. S.	1st Wed.	7:00	All year	Central Pub. Lib.	H. J. Carruthers, 427 S. E. 61 Ave.
"	†A. T. M. & O.'s	2nd Tue.	8:00	All year	Private homes	N. C. Smale, 831 N. Watts St.
PROVIDENCE, R. I.	Skyscrapers, Inc.	Mon. or Wed.	8:00	All year	Ladd Observatory	Ladd Obs., Brown U., *GA.* 1633
RENO, NEV.	A. S. of Nev.	4th Wed.	8:00	All year	Univ. of Nevada	G. B. Blair, University of Nevada
ROCHESTER, N. Y.	Roch. Ast. Club	Alt. Fri.	8:00	Oct.-May	Univ. of Rochester	Edwin M. Root, 110 Hamilton St.
ROCKY MOUNT, N.C.	Hi-Y A. C.	Tue.	8:00	....	YMCA	J. A. Harper, YMCA
RUTHERFORD, N. J.	Rutherford A. S.	1st Thu.	....	....	Private homes	W. C. Fillebrown, 273 Lawton Ave.
SACRAMENTO	*Sac. Val. A. S.	....	8:00	All year	Sacramento College	Mrs. Helen Schopke, 3111—12 Ave. (17)
SAN DIEGO, CAL.	Ast. Soc. of S. D.	1st Fri.	7:30	Oct.-June	504 Elec. Bldg.	W. T. Skilling, 3140 Sixth Ave.
"	†A.T.M. Ast. Club	2nd, 4th Mon.	7:30	All year	3121 Hawthorn St.	G. A. Sharpe, 4477 Muir, *Bayview* 3757
SCHENECTADY	S'tady Ast. Club	3rd Mon.	8:00	All year	Schenectady Museum	G. Staffa, 32 Front St.
SOUTH BEND, IND.	St. Jos'ph Val. Ast.	Last Tue.	8:00	All year	928 Oak Street	F. K. Czyzewski, South Bend Tribune
SPRINGFIELD, VT.	†Springfield T. M.'s	1st Sat.	6:00	All year	Stellafane	John W. Lovely, 27 Pearl St., 535-W
ST. LOUIS	St. Louis A. A. S.	1st Sat.	....	All year	Private homes	A. M. Obrecht, 2913 Park Ave.
STAMFORD, CONN.	Stamford A. A.	4th Fri.	8:00	All year	Stamford Museum	Wm. L. Dutton, Box 331, Noroton
TACOMA, WASH.	Tacoma A. A.	1st Mon.	8:00	All year	Coll. of Puget Sd.	Dorothy E. Nicholson, 2816 No. Union Ave.
TEANECK, N. J.	†Bergen Co. A. S.	2nd Wed.	8:30	All year	Obs., 107 Cranford Pl.	J. M. Stofan, 332 Herrick
TULSA, OKLA.	†Tulsa A. S.	Occasional meetings				V. L. Jones, 4-8462
WANTAGH, N. Y.	Long Island A. S.	Sat.	8:00	All year	Private homes	A. R. Luechinger, Seaford Ave., 1571
WARREN, OHIO	†Mahoning Val. A.S.	Thu.[4]	8:00	All year	Private homes	S. A. Hoynos, 1574 Sheridan, N.E., 25034
WASHINGTON, D.C.	†Nat'l Cap. Ast'mers	1st Sat.	8:00	Sept.-June	U.S. Nat'l. Museum	Jewell Boling, 1717 P St. N.W., *Du.* 2969
WICHITA, KANS.	†*Wichita A. S.	1st Wed.	8:00	All year	To be announced	Dollie Ratcliff, 801 Maple, 2-1822
WINSTON-SALEM	†*Forsyth A. S.	Last Fri.	7:30	All year	Private homes	Kenneth Shepherd, 703 W. E. Blvd.
WORCESTER, MASS.	†*Aldrich Ast. Club	1st, 3rd Tue.	7:30	All year	Mus. Natural History	Ralph A. Wright, 4 Mason St.
YAKIMA, WASH.	†Yak. Am. Ast'mers	1st Tue.	8:00	All year	Cha. of Comm. Bldg.	Edward J. Newman, 324 W. Yakima Ave.

[1]June, Jul., Aug., informal meetings. [2]Dinner meeting. [3]Nearest 1st-quarter moon. [4]1st or 2nd Sun., June-Sept.



DEEP-SKY WONDERS

THE OBJECTS this month all have a southern declination as we explore a section of the galactic center. Most of these have been noted in previous years and are repeated here on account of their prominence and beauty. Indeed, the total number of objects now recorded by Deep-Sky Wonders fills quite a respectable card file. **NGC 6093,** M80, $16^h\ 14^m.1$, $-22°\ 51'$, is one of the globular clusters in the great star fields of Scorpius, almost 20 degrees from the galactic equator. At 17½ kiloparsecs it lies at about average distance and would be much brighter were it not for the obscuration in the region.

NGC 6121, M4, $16^h\ 20^m.5$, $-26°\ 24'$, is only 7.2 kiloparsecs distant but the obscuration makes it faint. However, it is a fine, easily found globular cluster, splendid looking in even a 6-inch, and magnificent in anything above 10 inches.

NGC 6067, $16^h\ 9^m.4$, $-54°\ 5'$, is a grand galactic cluster only 3° from the galactic equator. In its 18′ diameter it includes over 120 stars brighter than magnitude 13.5, and to southern observers it is a favorite object. The whole region is thronged with bright clusters.

WALTER SCOTT HOUSTON

STARS FOR JUNE

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. For the year 1948, these simplified charts replace our usual white-on-black maps, which may be consulted in issues of prior years when information on deep-sky wonders and less conspicuous constellations is desired. Our regular charts for observers in the Southern Hemisphere appear in alternate issues.